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March 22, 2001

TO: Coastal Commissioners and Interested Parties

FROM: Jaime C. Kooser, Deputy Director
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RE: **Results of the Chevron 4H Platform Shell Mound Technical and Environmental Report**

Attached for your review and comment are the results of the Chevron 4H platform shell mound technical and environmental report[1] conducted by the consultant L. A. de Wit and prepared under the direction of the State Lands Commission ("SLC") and Coastal Commission staffs.

At the Coastal Commission's April 11, 2001 meeting, the consultant for the report, L.A. de Wit, will present the report's findings on the physical and chemical composition of the shell mounds, potential short- and long-term environmental impacts of mound removal as compared to in-place abandonment, and identification of shell mound removal options. The purpose of the hearing is for the Coastal Commission and interested members of the public to comment on the report's analysis and results. Interested parties may also submit written comments to either the SLC or Coastal Commission no later than April 13, 2001.

The Coastal Commission staff will schedule for a *future* *Commission hearing its recommendation as to whether removal of the shell mounds, or other mitigation measures, are necessary to avoid or mitigate impacts to commercial fishing.*

Shell Mound Study Background

Chevron's oil and gas production platforms Hazel, Hilda, Hope and Heidi (collectively known as the "4H platforms") were located in state waters in the eastern portion of the Santa Barbara Channel offshore of Santa Barbara County. In 1995, the SLC and the Coastal Commission approved the decommissioning of all four platforms. In 1996, Chevron removed most of the

[1] A copy of the shell mound report can also be obtained at the Coastal Commission's website at www.coastal.ca.gov. The report's technical appendix can be obtained at the Commission's San Francisco office.

platform structures (except for four buried 27-foot diameter Platform Hazel caissons). With the platform structures removed, the remaining site features are the shell mounds. These mounds consist of drilling muds and cuttings covered with a layer of mussel, clam and barnacle shells. The mounds are roughly semi-circular with diameters ranging from 55 meters to 82 meters.

The final phase of the platform abandonment project involved the removal of debris from the platform areas. Final site clearance was determined by test trawl surveys conducted using commercial bottom trawl fishing gear over the project site. The surveys determined that trawl gear could not cross the shell mounds without snagging. Both the SLC and Coastal Commission require that the site be "trawlable" as a condition of project completion. Special Condition 7 of coastal development permit ("CDP") E-94-6 states that "if the Executive Director determines that removal of the debris attributed to Chevron is necessary to avoid an unreasonable risk of snagging by trawl nets, this matter shall be set for public hearing before the Coastal Commission for the purpose of determining whether or not this coastal development permit shall be amended to require debris removal."

The attached report has been produced to provide both the SLC and Coastal Commission with the technical and environmental information necessary to evaluate options available for dealing with the mounds. For the Coastal Commission, the information gathered in the report is necessary for Coastal Commission staff to make a recommendation to the Coastal Commission as to whether the Coastal Commission should require Chevron to submit an amendment to CDP E-94-6 to remove the shell mounds. The standard of review as to whether an amendment is required is the policies of Chapter 3 of the Coastal Act.

Summary of Shell Mound Report Findings

The shell mound report concludes the following:

- The shell mounds at all four sites have similar physical characteristics comprising three distinct strata: an upper layer of shells, an intermediate layer of drill muds and cuttings, and an underlying layer of "native" seafloor sediments.

- An oily sheen and petroleum odor was present in several layers of muds and cuttings in all shell mounds.

- Sediment test results conclude that the Effects Range Medium ("ERM") concentrations for nickel and PCBs are exceeded at the Platform Hazel shell mound.

- The concentrations of metals and organics in the mounds at Platforms Hope, Heidi, and Hilda are not expected to be toxic to water column organisms. However, elutriate bioassay-testing results show that shell mound sediments at the Platform Hazel site are toxic enough at 48% concentration to kill 50% of the test organism, a mysid shrimp (*Mysidopsis bahia*).

- It is feasible to remove the shell mounds using a clamshell bucket dredge or by trawling using a Gorilla-type net or dragline dredge. Clamshell dredge may result in a re-suspension of contaminated materials. Trawling could also result in re-suspension of contaminated material and would spread the shell mound material over a larger area. (*See Table 10 on page 25 of the report for a comparison of each removal method*.)

- Capping of the mounds could also isolate the contaminated material. The report estimates that between 611,505 and 1,432,386 cubic yards of material would be necessary to cover all four mounds. Some capping material would extend onto the natural seafloor beyond the mounds.

- Shell mound-associated biota appears to have decreased in species richness and abundance since removal of the platforms. The shell mounds in their current form (absent the platform structures) provide limited biological habitat value. Removal of the mounds would not result in the loss of significant or unique biological resources. The macroepibota associated with the mounds is dominated by the bat star (*Asterina miniata*) while fish and the gorgonian coral *Lophogorgia chilensis* are more abundant around an exposed concrete leg at the Platform Hazel site and near an exposed pipeline at the Platform Hilda site.

- Removal of the four mounds would add 6.4 square nautical miles of halibut trawling areas, an increase of about 20% over that which is now available within Fish Block 652. Opening additional area to trawling could result in alteration of the epibota, smoothing of the seafloor, increase near-bottom turbidity, reduced water column dissolved oxygen concentrations, and release of contaminants from the surficial sediments into the water column.

- The major water quality impact of removal would be re-suspension of contaminated material. Some petroleum could be released resulting in the potential for an oily sheen to appear on the sea surface. Of particular concern would be the removal of the mound at Platform Hazel due to the concentrations of petroleum, nickel and PCBs.

- Under worse case conditions, shell mound removal would likely result in exceeding the state standard for PM_{10} emissions.

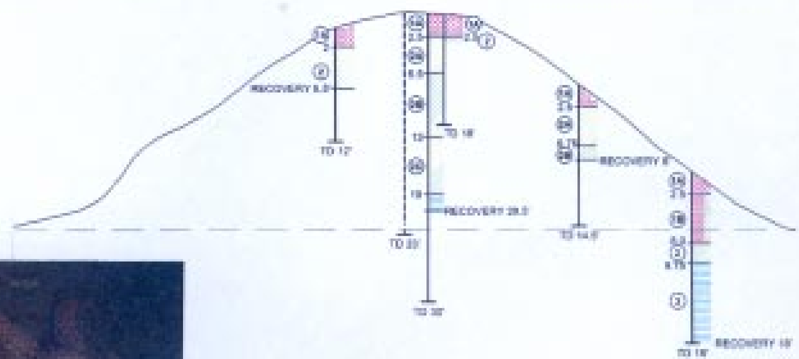
- It is not clear whether shell mound contaminants are leaching into the water column.

- Neither commercial nor recreational fishers are expected to benefit from the continued existence of the shell mounds.

SHELL MOUNDS ENVIRONMENTAL REVIEW

VOLUME I

FINAL TECHNICAL REPORT



Prepared for:
The California State Lands Commission
and
The California Coastal Commission

Bid Log Number RFP99-05

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EXECUTIVE SUMMARY

Field and literature data were collected to assess the existing and historical environmental characteristics of shell mounds, seafloor features created from several sources, under four previously removed offshore oil and gas platforms in the Santa Barbara Channel. The primary objectives of the study were to:

- collect and analyze data on the physical, chemical, and biological characteristics of the shell mounds,
- identify feasible methods of removing the features and,
- assess potential impacts to various resources from shell mound removal and from their continued existence in-place.

Biological data was collected by video and still cameras mounted on a remotely operated vehicle (ROV); physical and chemical characteristics were assessed from the analyses of cores taken at several locations on each shell mound; and impact assessment was based on the characteristics of feasible removal methods and on the results of the laboratory analyses of the site-specific data.

Physical Characteristics Fifteen sediment core samples, ranging from 11.5 to 30.0 ft (3.5 to 9.1 m) in length, were collected during the five days of vibrocoring at the shell mounds. Natural-bottom sediments were collected in 12 of the 15 samples, with the remaining three samples meeting resistance within the shell mound prior to penetrating the underlying natural sediments. Analysis of the cores indicate that the shell mounds at all four sites had similar physical characteristics, comprising three relatively distinct strata: 1) an upper layer of shell hash, 2) an intermediate layer of drill cuttings, and 3) the underlying “native” seafloor sediments (marine shelf deposits). The shell hash strata comprised mussel, clam, and barnacle shells up to several inches in length with variable amounts of black clay infilling. The intermediate stratum was inter-layered with drill cuttings and muds consisting of sandy clay, and clayey to silty sand with variable amounts of gravel-size siltstone rock fragments. Pockets of oil sheen/petroleum odor were present within this stratum. The natural seafloor sediment was medium-stiff to stiff olive green clay, with small shell fragments. The shell mound material is relatively unconsolidated and was readily penetrated by the vibrocore.

Using data from regional and near-site sedimentation studies, the estimated range of sediment accumulation at the former Platforms *Hazel* and *Hilda* sites is 0.4 to 0.6 inches (1.0 to 1.5 cm) per year, and from 0.6 to 0.8 inches (1.5 to 2.0 cm) per year at the former locations of Platforms *Hope* and *Heidi*. Comparing the sediment cover in the 1998 video footage at the shell mounds corroborates these data with that recorded during this survey. Erosion around the base of the shell mounds is not obvious from the bathymetric surveys conducted over the past five years.

Chemical Characteristics Sediment chemistry analyses were conducted on samples from each strata (Stratum 1=shell material; Stratum 2=drilling material; and Stratum 3=natural bottom) from each platform and for sediment taken from a reference site in the same water depth range as the platform sites. Elutriate testing was completed on composite cores on the same strata as the sediment testing, and elutriate bioassay tests were completed on Strata 1 and 2 at each of the four shell mounds (total of four elutriate bioassay tests). Laboratory analyses indicated the Effects Range Median (ERM) concentration for Nickel was exceeded in the Strata 1 and 2 sediments at one or more sites and for PCB in Stratum 1 at one site. The highest concentrations of all of the heavy metals, Total Recoverable Petroleum Hydrocarbons, and Polynuclear Aromatic Hydrocarbons within all of the strata, including the natural sediments underlying the shell mound material, exceeded the reference site sediments. Sediments in Stratum 1 had the highest concentration of 12 of the 30 analytes, including eight heavy metals or organic compounds that have established Effects Range Low (ERL) concentrations, while Stratum 2 sediments had the highest concentration of nine analytes, three of which have established ERLs. The natural sediments underlying the shell mounds had the highest concentration for six analytes, none of which have established ERLs. Two analytes were not detected in any of the strata sediments.

Elutriate bioassay-testing results showed that the shell mound sediments at the Platform *Hazel* site were toxic enough at 48% concentration to kill 50% of the test organism, a mysid shrimp (*Mysidopsis bahia*) within 96 hours. Although the sediment sampling protocol did not follow strict permitting agency requirements for determining suitability for

offshore disposal, it appears that Strata 1 and 2 have relatively high concentrations of several metals and organics and would not meet offshore disposal criteria.

Biology and Habitat A total of 250 minutes of videotape and 95 underwater still photographs were taken during the two-day field survey. Video footage of 12,320 ft^2 (1,145 m^2), comprising 1,722 ft^2 (160 m^2) of sedimentary habitat and 10,598 ft^2 (985 m^2) of shell and mixed shell/sediment habitat, was recorded during the ROV survey. The macroepibiota associated with the shell mounds at all four sites and on an exposed concrete platform leg at the Platform *Hazel* site was dominated by the bat star, *Asterina miniata*, and the gorgonian coral *Lophogorgia chilensis*. A few rockfish, *Sebastes* spp. were observed around the features. Fish and the gorgonian coral were more abundant around and on the exposed concrete leg. A solitary coral, *Coenocyathus* cf. *stearnsii*, was present to common on the exposed shells around the perimeter of the shell mounds. The value of the shell mounds as a habitat for most marine organisms has decreased since the 1998 survey and has been substantially reduced from that found when the platforms were in-place.

Commercial and Recreational Fishing The commercial fish catch within Fish Block 652, the California Department of Fish & Game reporting area that encompasses the four shell mounds from 1995 through 1999 indicates that bottom-oriented catch includes trapping for crab and lobster, and trawling for halibut, sea cucumbers, and ridgeback shrimp. Over the past five years, some commercial fishing claims that attribute gear damage to the shell mounds have been submitted. Recreational fishing is limited around the shell mounds; the features are fished only when other sites have been less productive. The sport catch at the shell mounds usually consists of brown and calico rockfish, although most have been relatively small individuals.

Methods of Removal Based on the physical characteristics of the shell mound material, several methods of removal appear to be feasible. Research into various methods used in similar operations indicate that excavation, either through a bucket or clamshell dredge, could be used to remove the shell material and the drilling muds and cuttings found within the mounds. Cement material was found within the mounds and one concrete platform leg was observed at the Platform *Hazel* site and could be problematic for most removal methods. These features appear to be too large or too firmly imbedded into the seafloor to be removed by excavation and would likely require fracturing prior to removal. A trawl net-type device is also feasible for removing most of the material, although larger items (*i.e.* concrete and steel) would likely require alternative removal equipment, and that method could result in spreading the material over a larger area. Capping of the material is also feasible, but would require detailed engineering to determine the slope angle and cap volumes. Removal of the material by the two preferred methods is expected to take from 15 to 60 days, while capping operations could take from 31 to 71 days to complete depending upon the slope desired.

Impacts of Removal The shell mound-associated biota appears to have decreased in species richness and abundance since the removal of the platforms; the biological value of the shell mound habitat is relatively low. As discussed above in Biology and Habitat, removal of the shell mounds will not result in the loss of any significant or unique biological resources. The removal of all four of the shell mounds will result in an additional 6.4 square nautical miles (22.3 km^2) of halibut trawling area, an increase of approximately 20% over that which is now available within Fish Block 652. The impacts of the preclusion area, estimated to be approximately 1 nmi^2 per site, during removal or capping operations is considered relatively short term (total period estimated to be from 30 to approximately 70 days), but significant. Fishers currently avoid from an area 0.5 to 1.0 nmi beyond each of the shell mounds. Opening of the additional trawl area will expose the sedimentary habitat and associated biota to trawl impacts similar to those experienced in the existing trawlable area. Those impacts could include alteration of the epibiota, smoothing of the seafloor, and resuspension of sediments possibly resulting in increased near-bottom turbidity, reduced water column dissolved oxygen concentrations, and release of contaminants from the surficial sediments into the water column. The loss of the shell mounds is not considered significant to the recreational fishing industry.

Water clarity immediately around the sites would be expected to be reduced during removal or capping activities. Elutriate bioassay tests of Platform *Hazel* shell mound sediments showed the material to be toxic the mysid shrimp used in the tests. Resuspension of those sediments, that had high concentrations of petroleum, and, for example, Nickel, and PCBs could produce toxic effects to sensitive organisms (plankton, including fish larvae) within the plume. Petroleum found within the shell mound sediments could be released during excavation, resulting in an oily sheen on the water surface. The synergistic effects of the contaminants detected in the sediments makes impaired water quality likely if the Platform *Hazel* shell mound is removed or substantially disturbed. Elutriate testing of the sediments from the other three mounds found no mysid toxicity and, if removed, could result in local turbidity increases, but no substantial toxicity is expected. The complex and variable currents in the area preclude quantitative assessment of dispersal of the sediments during removal, however, based on regional studies, the prevailing currents would be expected to disperse the sediments to the west. Some contaminants would adhere to the fine sediments and/or would be released into the water column. Based only on a single elutriate test, contaminants from Platforms *Hope, Heidi, and Hilda* would not be expected to be toxic to water column organisms. Uncontrolled capping of the *Hazel* shell mound could, however, release contaminants at concentrations to have toxic effects on planktonic organisms, including larval fish, in the sediment plume.

Short-term air emissions are expected to be similar to those modeled for platform removal with the state PM_{10} standard being exceed for all three alternative shell mound removal methods assessed. Of the three, the clamshell dredge method of removal is expected to result in the highest air emissions.

Impacts of Non-Removal The continued presence of the shell mounds is expected to provide limited habitat value to a biological community similar to that observed, however, the relative abundance of those species would likely ~~remain~~ continue to decrease over time. If the shell mounds are to remain in-place, enhancement of the existing habitat value through the addition of artificial solid structure is possible. Leaving the shell mounds in-place will continue to limit the available halibut trawling area within Fish Block 652 and, unless the mounds are enhanced with artificial substrate, the mounds are expected to provide habitat of limited value for commercial species. Likewise, without habitat enhancement, the recreational fishery is not expected to realize substantial benefits from the continuing presence of the shell mounds. While the chemical analyses do not provide definitive evidence that contaminants are migrating through the shell mounds and into the water column, compared to reference sediments, the natural sediments underlying the shell mounds have elevated levels of several contaminants. The highest concentrations of contaminants of most concern, those with established ERL or ERM, were found in Strata 1 and 2. The concentration of eight such contaminants exceeded the ERL in Stratum 1 while seven contaminants exceeded the ERL concentrations in Stratum 2. Assuming that natural sedimentation will be insufficient to "naturally cap" vertically-migrating contaminants (if such migration is occurring), metal and organic levels would be expected to slowly decrease through biological and physical degradation.

An option to leaving the shell mounds in-place and in their existing configuration is to cap each mound with a layer of "clean" sediment. Capping would necessitate covering the shell mounds and some area of natural seafloor around each mound. The areal extent of the seafloor covered would depend upon the final design of the cap and the desired slope, but would be expected to range from 465.6 to 696 ft (142 to 212 m) around all sides of the mounds. With a 3-ft (1 m) deep cap at the apex of each mound, the depth of the capping material on the natural seafloor would be less than 1 ft (0.3 m).

Air quality is not expected to be negatively impacted by the continuing existence of the shell mounds.

1.0 __INTRODUCTION__

The following discusses the results of a literature search and the collection and analysis of field data on the existing biological, chemical, and physical characteristics of shell mounds located on the seafloor below four previously-removed oil and gas production platforms in the Santa Barbara Channel. Figure 1 shows the location of the four platforms, *Hope*, *Heidi*, *Hazel*, and *Hilda*, which were located in water depths ranging from approximately 95 ft (29 m) to 150 ft (46 m). The four platforms were shut-in in 1992 and subsequently removed in 1996. The shell mounds were formed from drilling-related discharges and from the deposition of epibiota that had fallen from their attachment points on the submerged portions of the platforms. The biological community associated with the platforms and shell mounds at these sites has been the subject of several earlier studies including Bascom, *et al.*, 1976; Carlisle, *et al.*, 1964, Simpson, 1977, and Turner, *et al.*, 1969. de Wit, 1999 documented the biota associated with the shell mounds in 1998, two years after the platforms were removed.

Previous studies have indicated that shell mounds, in conjunction with the platforms, provided a valuable biological habitat while at the same time, were and still are considered seafloor hazards by commercial trawlers. Additionally, removal of the mounds and the possible resuspension of potentially toxic material within the shell mounds (*i.e.* drill cuttings and drilling fluids) could be problematic. No quantitative data on the chemical and physical composition of the shell mound material at these sites has been previously reported.

Based on the aforementioned studies and on the need to ascertain the composition of the shell mounds, the California State Lands Commission, in association with the California Coastal Commission (commissions), contracted L. A. de Wit, Consultant to collect and analyze site-specific data and to provide the results of laboratory analyses of field samples in a technical report. In addition to presenting the results of the field data collection and analyses, the commissions requested a listing of potential methods of shell mound removal and an assessment of potential environmental impacts to air and water quality, biological resources and habitat, and commercial and recreational fishing from removing the mounds and from allowing the shell mounds to remain in-place. The study objectives as written in the Request for Proposal are provided below.

The report was designed to assist the commissions in deciding the final disposition of the shell mounds. Volume I of this two-volume report discusses methods used for data collection and analyses, and the results of literature surveys and laboratory analyses completed for this study. Complete copies of laboratory analyses, special technical reports, and supporting information are provided in Volume II (Appendices).

2.0 *__STUDY OBJECTIVES__*

As specified in the Request for Proposal, the objectives of the study were:

- <u>Physical characterization of the mounds</u>: Summarize existing literature data on the size and shape of the mounds, collect sediment samples from within the mounds, and complete physical and chemical laboratory analyses on those samples.
- <u>Sedimentation and scour rates</u>: Complete a literature-based technical report on the anticipated rate of sediment deposition onto and erosion rates around the shell mounds.
- <u>Habitat assessment</u>: Complete a literature review and collect site-specific field data on the biological community associated with the shell mounds. Use those data to assess the value of the shell mound habitat and compare the existing habitat and associated biota with previously reported conditions.
- <u>Feasible methods of removal</u>: Research methods that had been used to remove similar seafloor features and determine the applicability and feasibility of each method for use at the four Santa Barbara Channel sites.
- <u>Impact assessment</u>: Utilize information collected during the field surveys, laboratory analyses, and literature search to assess potential impacts to air and water quality, biological resources and habitat, and commercial and recreational fishing that could result from removing the material and from leaving the shell mounds in-place.

3.0 *FIELD EQUIPMENT AND PERSONNEL*

3.1 VIBROCORING SURVEY

The vibrocoring operations were conducted from the MV *Danny C.*, a 76-ft (23 m) converted supply vessel; anchor placement assistance provided by the *Julia*, a 45 ft (14 m) tug. Both vessels were owned and operated by Castagnola Tug Service, Inc., Santa Barbara, California. The vibrocore, owned and operated by TEG Oceanographic Services, Inc., Monterey, California, comprised a pneumatic head, fitted to a 30 ft- (9.1 m-) long, 4.0 inch (in) (10.2 cm)-diameter steel core barrel lined with a 3.5 in (8.9 cm) diameter butyl liner. A 40 ft- (12 m-) long, aluminum frame, fitted with four collapsible aluminum legs supported the core and pneumatic head (see Plate 1).

Navigation of the vessel and positioning of the anchors was accomplished with a Starfix II Wide Area Differential GPS, owned and operated by Fugro-West, Ventura, California. At Platforms *Hazel*, *Hilda*, and *Heidi*, a three-point anchoring system was used; a four-point anchoring system (two bow anchors and two stern anchors) was used at Platform *Hope*. The pre-positioning of anchors was required at the *Hope* site in order to avoid anchor line contact with two active subsea pipelines located immediately east of the shell mound. Surface (crown) buoys were attached to all anchors to aid in recovery upon completion of coring activities.

3.2 ROV SURVEY

The remotely-operated vehicle (ROV) video and still photographic survey was also conducted from the MV *Danny C.* A Phantom HD 2+2 ROV, owned and operated by Inshore Divers, Inc. of Pittsburg, California and fitted with a laser measuring device, a short-range scanning sonar, color and black and white video cameras, a 35 mm still camera, and flood and strobe-flash lighting, was used to obtain photographic records of the shell mounds. The survey vessel navigation system comprised a Starfix II Wide Area Differential GPS and the ROV was positioned utilizing an ORE 4220 Trackpoint II acoustic tracking system that was integrated into the vessel DGPS. A Robertson SKR-82 Gyrocompass was used to compensate for vessel heading and for offsets of the acoustic tracking system. All navigation equipment was owned and operated by Fugro-West, Inc. of Ventura, California. Details on the equipment used for this survey are provided in Volume II, Appendix A.

A list of the personnel who were onboard the survey vessel during the ROV and vibrocoring surveys is provided in Volume II, Appendix A.

4.0 *METHODS*

4.1 VIBROCORING SURVEY

4.1.1 Field Operations

Prior to initiating the survey, proposed vessel anchor and coring locations were pre-plotted on bathymetric maps, and a survey plan was submitted to and approved by the commissions. A Notice to Mariners was provided to the U.S. Coast Guard, and a Notice to Fishermen was posted at the Harbor Master's offices at Ventura, Channel Islands, Port Hueneme, and Santa Barbara harbors. At the Platform *Hazel, Hilda,* and *Heidi* locations, the tug placed the two stern anchors at their respective pre-plotted locations, then the *Danny C.* moved forward to place the bow anchor. Shortening or lengthening the anchor lines until the stern of the Danny C. was directly over the specified core location made adjustments to the vessel location. To avoid potential damage to two active pipelines near the shell mound, four, pre-positioned anchors were used to maintain vessel position at the Platform *Hope* site.

Onboard operations consisted of placing a core liner into the core barrel, and deploying the vibrocore frame and core from the stern of the vessel (see Plate 2). To assist onboard personnel in determining when the vibrocore had reached the seafloor, a small video camera was secured to one of the vibrocore legs and hard-wired to an onboard video monitor. The camera was oriented toward the core barrel to provide real-time observations of the actual penetration into the shell mounds. Upon refusal (no further penetration) or when the core barrel had penetrated 30 ft (9.1 m) into the shell mound, the vibrocore was recovered, the core line removed, and the sample extruded into on-deck plastic sample holders (see Plates 3, 4 and 5).

Following extrusion of the core, the onboard geologists logged and photographed the sample, identified and labeled the strata (layers of differing sediment types), and took samples from each strata. The onboard chemistry laboratory technicians also collected samples from each strata and placed the labeled containers into ice chests. Sediment samples that were to be used for chemical analyses were maintained at 4°C and samples to be used for physical analyses were placed in labeled plastic bags. All samples were delivered to respective laboratories at the end of each field day. A log of vibrocoring field operations is provided in Volume II, Appendix B.

4.1.2 Laboratory Procedures

Geotechnical laboratory analyses comprised a series of tests to determine engineering properties of the sampled materials. Composite sample testing included moisture content, grain size, Atterberg limits, and specific gravity. All geotechnical testing was completed in general accordance with the American Society for Testing and Materials (ASTM) Standards for soil testing at Fugro-West's laboratory in Ventura, California.

Chemical analyses and bioassay testing was completed by or under the direction of Aquatic Bioassay & Consulting Laboratories, Inc. (ABC), Ventura, California. Sediment chemistry and elutriate analyses were completed by CRG Marine Laboratories, Inc., Terminal Island, California using EPA-approved methods. A description of the specific methods used is provided in ABC Laboratories' technical report in Volume II, Appendix D. Reference sediment was collected at a site offshore Goleta in similar water depths and was analyzed using the same methods as those for the shell mound strata.

4.1.2 Air Quality Assessment

The results of emission calculations from the Offshore Coastal Dispersion (OCD) model, a modeling protocol used by the Santa Barbara County Air Pollution Control District (APCD), for the equipment used to remove the four platforms were used as a basis for assessing potential emissions from the feasible shell mound removal methods. The percent difference between the maximum short-term emissions for each alternative and the maximum short-term emissions from the previously-completed abandonment were calculated. Using equipment descriptions, emission factors, and duration of engine use for each alternative, the calculated percentage was applied. Worse case emissions were based on the assumption of simultaneous operations of all equipment for each alternative.

4.2 ROV SURVEY

4.2.1 Field Operations

Prior to initiating the ROV survey the following was completed:

- proposed ROV survey lines were pre-plotted on bathymetric maps,
- a survey plan was submitted to and approved by the commissions,
- a Notice to Mariners was provided to the U.S. Coast Guard, and a Notice to Fishermen was posted at the Harbor Master's offices at Ventura, Channel Islands, Port Hueneme, and Santa Barbara harbors.

Dr. Craig Fusaro, Fisheries Liaison Officer (Santa Barbara) was also contacted and apprised of the forthcoming operations. Copies of the various notices and authorizations are provided in Volume II, Appendix A.

Following mobilization and testing of the ROV in Santa Barbara, video and still-photography transects were completed at each of the four shell mound sites. Upon arrival at each site and prior to deploying the ROV, the location of a maker buoy that had been placed on each shell mound was recorded; pre-locating the buoy allowed the ROV operator to avoid entangling the ROV cable with the buoy line. The ROV was then manually deployed through a "cut-out" on the starboard side of the *Danny C.* and real-time video was observed by two onboard biologists, Messrs. Ray de Wit and Rick Ware. The vessel was not anchored and navigation fixes were taken at 30-second intervals along all transects. Following the survey, the actual transect lines were plotted by Fugro-West. A log of the ROV survey field activities is provided in Volume II, Appendix B.

5.0 ***RESULTS***

5.1 PHYSICAL AND CHEMICAL CHARACTERIZATION

5.1.1 Physical Characterization

Fifteen sediment core samples, ranging from 11.5 to 30.0 ft (3.5 to 9.1 m) long, were collected during the five days of vibrocoring at the shell mounds. The vibrocore advanced through the strata and to refusal in two to three minutes, with noticeable slowing of the penetration rate upon reaching the underlying natural seafloor sediments. Natural-bottom sediments were collected in 12 of the 15 samples, with the remaining three samples meeting resistance within the shell mound prior to penetrating the underlying natural sediments. Sample recovery was typically about 70 percent of the total penetration depth. One sample was lost at the Platform *Hazel* site when the core barrel separated. No samples were collected at two other sites when the vibrocore toppled at steeply-sloped sample locations. Volume II, Appendix B includes figures of the core locations at each of the sites.

Analysis of the cores indicate that the shell mounds at all four sites had similar physical characteristics, comprising three relatively distinct strata: 1) an upper layer of shell hash, 2) an intermediate layer of drill cuttings and fluids (muds), and 3) the underlying "native" seafloor sediments (marine shelf deposits). Table 1 provides a description of each of the strata observed.

Table 1
Summary of Shell Mound Strata

Strata	Subdivision	General Description	Stratum Thickness in Vibrocore in feet (m)
1) Shell Hash	1a: Primarily shells with minor amounts of clay. 1b: Approximately equal mixture of shells and clay.	Mussel, clam, and barnacle shells up to several inches in diameter with variable amounts of black clay infilling.	1 to 7 (0.3 to 2.1)
2) Drill Cuttings	2a through 2e (as necessary) subdivide distinct pockets of cuttings.	Inter-layered sandy lean[1] to fat[2] clay (CL/CH), and clayey to silty sand (SC/SM) with variable amounts of gravel-size siltstone rock fragments, with pockets of oil sheen/petroleum odor.	0 to 18 (0 to 5.5)
3) Seal Floor Sediments	Fairly uniform clay, no subdivisions.	Lean to fat clay (CL/CH), olive gray, medium stiff to stiff, with small shell fragments.	0 to >10 (0 to >3.1)

[1]Lean=low plasticity
[2]Fat=high plasticity

Subdivisions were not present in all samples, however, where present, they were identified on the basis of stratigraphy. Cross-sections of the four shell mounds are shown in Figures 2 through 5; the cross-sections are along the east-west axis of each shell mound (see Plates 2a through 2d in Fugro West's report, Volume II, Appendix D). Using recent bathymetric data, the heights of the mounds range from 20 to 28 ft (6.7 to 8.5 m), and from 185 to 230 ft (56.9 to 70.1 m) wide. Estimated volume of the material within the shell mounds range from 7,000 to 14,000 yd^3 (5,352 to 10,704 m^3).

Stratum 1 was typically one to two ft (0.3 to 0.6 m) thick near the apex of the mounds and increased in thickness on the sides and near the base of the mounds. There was an oily sheen at the base of some of the Stratum 1 samples. Material within both subdivisions of this stratum had a strong organic odor, and was "loose", failing to retain its integrity when the sample was extruded into the sampling tray. Clayey material comprised approximately 10 to 35 per cent of this stratum.

Stratum 2 was typically 0.2 to 0.5 ft (<0.1 to 0.2 m) thick, but in some cases several feet thick, comprising a mixture of siltstone rock fragments, clay and fine sand, fine- to coarse-grain sand, and fine-grain sediments. The siltstone appears to be cuttings, while the finer sediments are likely a combination of drilling mud and material developed during the drilling process. An oily sheen and petroleum odor were present in several of the layers, being most obvious in the medium- to coarse-grain sand lenses. Grain size analyses indicated that 30 to 60 percent of the sample passed through a No. 200 sieve (greater than 50 percent passing indicates a fine-grain silt or clay classification). Atterberg limit tests indicate the finer-grained components of this stratum are lean to fat clay, with a higher percentage of fat clay samples. The substrata varied in stiffness, with the soft to medium-stiff sandy clays (drilling mud) being the stiffest; soft clay and loose sand layers were relatively unconsolidated.

Stratum 3 was the natural seafloor sediment, comprising layers of olive gray, medium-stiff clays with numerous small shells and shell fragments. Grain size analyses indicated that most of the material was silt and clay; Atterberg limit tests indicated the material was lean to fat clay. This stratum comprised approximately 90 per cent clayey material. Pocket penetrometer, torvane, and unconfined compression shear strength tests for the natural sediments recovered at Platform *Hope* indicate a shear strength range of 250 to 600 pounds per square foot. Material with that shear strength range would be amenable to dredging. No sheer tests were conducted on the shell mound material as it was too unconsolidated. Based on the onboard geologist's observations of the cores, the shell mound material could be removed by standard dredging methods.

Grain size curves for the three strata are shown in Figure 6. Core logs of each of the vibrocore samples are provided in Volume II, Appendix C, and photographs of the cores are provided in Fugro-West's report in Volume II, Appendix D.

5.1.2 <u>Chemical Characteristics</u>

Sediment chemistry analyses were conducted on samples from each strata (Strata 1=shell material; Strata 2=drilling material; and Strata 3=natural bottom) from each platform and for sediment taken from a reference site in the same water depth range as the platform sites. Elutriate testing was completed on composite cores on the same strata as the sediment testing, and elutriate bioassay tests were completed on Strata 1 and 2 at each of the four shell mounds (total of four elutriate bioassay tests). A summary of the sediment chemistry is shown in Table 2; Table 3 lists location of sediments that exceeded ERL and/or ERM levels by platform and strata. Summary elutriate data is provided in Table 4. Complete laboratory results are provided in the ABC Laboratories' report in Volume II, Appendix D.

Table 2
Summary of Sediment Test Results
Range of Concentration of Metals and Organics

Metals (ppm)	**Strata 1**	**Strata 2**	**Natural Sediment**	**Reference**	**ERL-ERM**[2]
Aluminum (Al)	3,710-24,900	11,200-21,400	19,700-*35,400*[1]	11,800	N/A
Antimony (Sb)	0.36-*8.04*	0.31-3.32	0.22-0.30	0.15	2.0-25.0
Arsenic (As)	2.72-*8.33*	3.39-7.35	5.52-8.24	3.56	8.2-70.0
Barium (Ba)	1,280-18,600	2,310-*20,000*	191-1,330	93	N/A
Beryllium (Be)	0.16-0.50	0.23-0.34	0.41-*0.64*	0.23	N/A
Cadmium (Cd)	0.36-*3.26*	0.46-2.94	0.41-0.55	0.47	1.2-9.6
Chromium (Cr)	43.6-168.0	108.0-*173.0*	48.9-66.6	28.0	81.0-370.0
Cobalt (Co)	2.12-6.86	5.09-7.16	6.03-*9.82*	2.56	N/A
Copper (Cu)	15.7-*46.4*	18.7-37.4	11.9-21.5	5.45	34.0-270.0
Iron (Fe)	8,320-27,600	11,300-25,200	23,400-*37,900*	12,500	N/A
Lead (Pb)	9.89-*82.6*	11.1-71.8	6.93-10.3	4.28	46.7-218.0
Manganese (Mn)	145.0-329.0	189.0-*373.0*	203.0-283.0	100	N/A
Mercury (Hg)	0.029-0.096	0.024-*0.11*	0.022-0.051	0.03	0.15-0.71
Molybdenum (Mo)	2.66-11.00	2.04-*15.20*	0.90-1.60	0.59	N/A
Nickel (Ni)	12.4-**72.1**	21.9-***79.6***	32.2-41.4	18.3	20.9-51.6
Selenium (Se)	0.85-*3.12*	0.50-2.74	ND[3]-3.09	1.92	N/A
Silver (Ag)	0.08-*0.48*	0.11-0.42	0.05-0.08	0.05	1.0-3.7
Thallium (Tl)	0.09-0.41	0.12-0.35	0.30-*0.47*	0.26	N/A
Tin (Sn)	0.95-*5.39*	0.92-1.72	1.05-1.61	0.71	N/A
Titanium (Ti)	355.0-892.0	433.0-869.0	1,060-*1,360*	674	N/A
Vanadium (V)	17.4-136.0	25.4-*147.0*	70.5-108.0	30.6	N/A
Zinc (Zn)	58.8-*223.0*	51.4-185.0	52.1-86.8	31.3	150.0-410.0
Organics					
Polynuclear Aromatic Hydrocarbons (ppm)	0-20.8	3.36-*38.4*	0.044-0.432	0.028-0.045	4.02-44.79
Total DDT	0	0	0	0	1.58-46.1
PCBs (ppm)	ND-*0****910***	ND	ND	ND	0.0227-0.180
Phthalates (ppm)	0.062-1.345	0.122-*1.732*	0.034-0.125	0.143	N/A[4]
Phenols	ND	ND	ND	ND	N/A
Acid Volatile Sulfides (ppm)	428.0-*1,210.0*	12.4-120.0	0.2-5.3	52.7-57.3	NA
Total Recoverable Petroleum Hydrocarbons (ppm)	212-*32,900*	1,960-14,500	448-725	502-519	N/A
Total Organic Carbon (per cent dry weight)	0.71-3.19	0.94-*4.50*	0.05-1.19	0.98	N/A

[1]Highest concentration shown in italics; underlined if exceeds ERL; **bold** if exceeds ERM
[2]ERL=Effects Range, Low after Long *et al.*, 1995 (chemical concentrations below ERL not expected to have an effect); ERM=Effects Range, Median after Long, *et al.*, 1995 (chemical concentration at which effects are expected to occur).
[3]ND=Not detected.
[4]N/A=No ERL or ERM established.

In reviewing the data in Table 2 and comparing analyte concentrations within the shell mound strata with those found in the reference site sediments, several conclusions can be made:

1) No Reference sediments had concentrations that exceeded the Effects Range Low (ERL) levels.
2) The Effects Range Median (ERM) concentration for Ni was exceeded in the Strata 1 and 2 at one or more sites and for PCB in Stratum 1 at one site.
3) Stratum 1 sediments had the highest concentration of 12 of the 30 analytes, including eight that have established ERLs.
4) Stratum 2 sediments had the highest concentration of nine analytes, three of which have established ERLs.
5) Natural sediments had the highest concentration for six analytes, none of which have established ERLs. Two analytes, DDT and Phenols, were not detected in any of the strata sediments.

Although no data is known on the sediment contaminant levels at the sites prior to the platform placements, the heavy metal concentrations in the reference sediment are lower than those in the natural sediments underlying the shell mounds. These data suggest that contaminants within Stratum 2 are migrating down into the relatively stiff, clayey natural sediments. A series of sediment testing, that would provide information on changes in contaminant concentrations within each stratum over time, is, however, necessary to substantiate that observation.

Table 3 lists the strata and shell mound within which ERL or ERM concentrations were exceeded.

Table 3
Location of Sediments Exceeding the ERL or ERM Concentrations for Metals and Organics by Strata[1,2]

Metals (ppm)	Strata 1	Strata 2	Natural Sediment
Antimony (Sb)	Heidi (8.04)	Hilda (3.32)	None[3]
Arsenic (As)	Hazel (8.33)	None	None
Cadmium (Cd)	Hilda (3.26) Hazel (1.62)	Hilda (2.94) Hazel (1.81)	None
Chromium (Cr)	Hazel (168.0) Heidi (141.0)	Hilda (173.0) Hope (171.0) Hazel (109.0) Heidi (108.0)	None
Copper (Cu)	Hazel (46.4)	Hilda (37.4) Hope (36.2)	None
Lead (Pb)	Hilda (82.6) Hope (65.8) Hazel (64.8)	Hope (71.8) Hazel (54.3) Hilda (49.8)	None
Mercury (Hg)	None	None	None
Nickel (Ni)	Hazel (**72.1**) Hilda (55.1) Heidi (26.7)	Hilda (**79.6**) Hazel (**52.1**) Heidi (23.9) Hope (21.9)	None
Zinc (Zn)	Hazel (223.0)	Hazel (185.0)	None
Organics			
PAH (ppm)	Hilda (20.8) Hazel (11,000)	Hazel (38.4) Hilda (19,000)	None
Total DDT	None	None	None
PCBs (ppm)	Hazel (**0.910**)	None	None
Total *Hazel*	**9**	**5**	**0**
Total *Hilda*	**4**	**7**	**0**
Total *Hope*	**1**	**4**	**0**
Total *Heidi*	**3**	**2**	**0**

[1] Includes only those analytes with established ERL or ERM concentrations.
[2] Underline=exceeds ERL, **bold**=exceeds ERM
[3] No sites met or exceeded established ERL or ERM concentrations.

Concentrations of the analytes in elutriate samples are provided in Table 4.

Table 4
Summary of Elutriate Chemistry Results
Concentration Range of Metals and Organics

Metals (ppb)	**Reference**	**Strata 1**	**Strata 2**	**Natural Sediment**
Aluminum (Al)	27.0-28.5	0.5-36.4[2]	ND[1]-49.1	1.3-*51.4*[3]
Antimony (Sb)	5.4-11.0	0.4-*16.9*	0.4-13.0	0.2-12.5
Arsenic (As)	3.2-13.9	ND-*11.4*	ND-11.2	ND-10.3
Barium (Ba)	16.6-16.8	23.7-*360.0*	51.9-212	7.0-94.4
Beryllium (Be)	ND	ND	ND	ND
Cadmium (Cd)	ND	ND	ND	ND
Chromium (Cr)	4.0-4.7	2.4-11.1	3.1-*37.9*	3.3-24.1
Cobalt (Co)	1.7-2.1	1.7-3.5	1.8-*3.8*	1.8-3.4
Copper (Cu)	23.9-25.6	18.3-*39.4*	21.3-38.9	20.5-38.0
Iron (Fe)	916.0-1,120.0	645.0-950.0	775.0-*1,060*	754.0-933.0
Lead (Pb)	ND	ND-0.3	ND-*1.0*	ND
Manganese (Mn)	6.9-8.0	ND-55.0	35.2-*233.0*	4.1-14.1
Mercury (Hg)	0.15-0.24	ND-*0.26*	ND-0.20	ND-0.09
Molybdenum (Mo)	12.9-13.9	24.3-38.4	19.1-*54.2*	14.0-16.4
Nickel (Ni)	4.0-5.8	4.3-6.9	*7.0-18.7*	4.9-6.8
Selenium (Se)	1.4-1.8	ND-*50.2*	ND-47.5	ND-41.3
Silver (Ag)	ND-0.13	ND-*0.17*	ND-0.15	ND-0.14
Thallium (Tl)	ND	ND	ND	ND
Tin (Sn)	ND-0.5	ND-*1.6*	ND-0.8	ND-0.7
Titanium (Ti)	6.9-23.9	7.3-*16.0*	7.8-15.6	7.6-13.7
Vanadium (V)	8.8-10.8	4.1-12.4	3.2-13.6	4.6-*14.3*
Zinc (Zn)	39.1-40.8	40.2-*84.0*	36.8-70.0	37.6-75.4
Organics				
PAH (ppb)	ND	ND-*1.231*	ND-0.848	ND-0.064
Total DDT	ND	ND	ND	ND
PCBs	ND	ND	ND	ND
Phthalates (ppb)	0.598	0.548-*1.033*	0.398.0-0.636	0.157-0.343
Phenols	ND	ND	ND	ND
Oil and Grease (ppb)	140.0	ND-3,350.0	13-*6,440.0*	ND-110.0
Dissolved Sulfides	ND	ND	ND	ND
TRPH (ppb)	ND	ND-2,020.0	ND-*2,600.0*	ND
Total Exceeding Reference Sediment Concentration	----	20	19	15

[1]ND=Not detected.
[2]Underlined values exceed highest concentration in Reference Sediment elutriate.
[3]Highest concentration shown in italics.

Table 4 data reveals the following:

1) Highest elutriate concentrations from reference sediment were less than or equal to shell mound strata concentrations for all analytes except for As, Fe, Hg, Ti, phthalates, and oil and grease.
2) Elutriate concentrations for Ba and Mo in all three strata exceeded reference sediment concentrations.
3) Elutriate concentrations for eleven heavy metals, PAH, and oil and grease exceeded the reference elutriate concentrations in one or more strata.

Combining the data from Tables 3 and 4 suggests the following:

1) Stratum 1 sediments had at least one site that exceeded the ERL concentrations for all analytes except Hg and DDT; Stratum 2 sediments exceeded ERL concentrations for all analytes except Hg, DDT, and PCBs.
2) Platform *Hazel* shell mound sediments exceeded the ERL or ERM concentrations for more analytes (14) than all other sites. Platform *Hilda* shell mound sediments was second (11).
3) The Stratum 1 sediments at the Platform *Hazel* shell mound exceeded ERL concentrations for nine of the twelve analytes with established limits and also exceeded ERM concentrations for Ni, and PCBs.
4) Stratum 2 sediments at the Platform *Hilda* shell mound exceeded ERL concentrations for seven analytes and, with Platform *Hazel*, exceeded the ERM concentrations for Ni.

5) The highest concentration of twenty of the thirty analytes in Strata 1 sediments exceeded the Reference Sediment. Of particular interest is the 21 fold increase in Ba, the 28 fold increase in Se, and the 1,200 fold increase in PAH.
6) The highest concentration of nineteen of the thirty analytes in Strata 2 exceeded the Reference Sediment, with Ba (13X), Mn (29X), and PAHs (848X) showing the largest increases over Reference Sediment concentrations.

The results of the elutriate bioassay testing indicated that only the shell mound material at the Platform *Hazel* site was toxic to the mysid shrimp test organism. The 96-hour Lethal Concentration resulting in 50% mortality (LC_{50}) was 48.57%, meaning that elutriate from the shell mound sediments at that site diluted to 48.75% was sufficiently toxic to kill 50% of the test organisms. The 96-hour LC_{50} for the other three sites exceeded 100%, indicating the maximum elutriate concentration was not toxic to the test organism at maximum concentration. Discussions with M. Machuzak, pers. comm. suggest that the toxicity of the *Hazel* sediments is likely due to the synergistic effects of the high sediment concentrations for several trace metals and organic compounds, including the relatively high concentration of Zn and PCBs.

Comparing the concentrations within the sediment with that in the associated elutriate samples provides some insight into which contaminants could be expected to be released into the water column and which remained “attached” to the sediments. The elutriate samples comprised seawater that had been mixed with the sediment then passed through a 0.45 micron filter. Table 4a provides the range of those concentrations and the sediment to elutriate ratio.

Table 4a
Contaminant Comparisons (Sediment and Elutriate) for Analytes with Established ERL and ERM Concentrations

Analyte	Shell Mound Sediments	Natural Bottom Sediments
Sb	Sediment=0.31 to 8.04 ppm, Elutriate=0.003 to 0.017 ppm Sediment to Elutriate Ratio=103 to 773	S=0.03 to 0.28 ppm, E=0.0002 to 0.013 S/E Ration=22 to 150
As	S=2.94 to 8.33 ppm, E=ND[1] to 0.011 ppm S/E Ratio=NA to 757	S=5.52 to 8.24 ppm, E=ND to 0.01 S/E Ratio=NA to 824
Cd	S=0.46 to 3.26 ppm, E=ND S/E Ratio=NA	S=0.41 to 0.55 ppm, E=ND S/E Ratio=NA
Cr	S=46.1 to 173.0 ppm, E=0.004 to 0.038 S/E Ratio=4,553 to 11,525	S=48.9 to 66.6 ppm, E=0.004 to 0.024 S/E Ratio=2,775 to 12,225
Cu	S=15.7 to 46.4 ppm, E=0.02 to 0.04 ppm S/E Ratio=785 to 1,160	S=11.9 to 21.5 ppm, E=0.02 to 0.04 ppm S/E Ratio=538 to 595
Pb	S=9.89-82.6 ppm, E=ND to 0.001 S/E Ratio=NA to 82,600	S=6.93 to 10.3 ppm, E=ND S/E Ratio=NA
Hg	S=0.03 to 0.11 ppm, E=ND to 0.0003 ppm S/E Ratio=NA to 367	S=0.02 to 0.05 ppm, E=ND to 0.00009 ppm S/E Ratio=NA to 556
Ni	S=15.0 to 79.6 ppm, E=0.005 to 0.011 ppm S/E Ratio=3,000 to 7,236	S=32.2 to 41.4 ppm, E=0.005 to 0.007 ppm S/E Ratio=5,914 to 6,440
Ag	S=0.09 to 0.48 ppm, E=ND to 0.0002 ppm S/E Ratio=NA to 2, 400	S=0.05 to 0.08 ppm, E=ND to 0.0001 ppm S/E Ratio=NA to 800
Zn	S=51.4 to 223.0 ppm, E=0.04 to 0.08 ppm S/E Ratio=1,285 to 2,788	S=52.1 to 86.8 ppm, E=0.04 to 0.08 S/E Ratio=1,303 to 1,085
PAH	S=ND to 38.4 ppm, E=ND to 0.12 ppm S/E Ratio=NA to 320	S=0.04 to 0.43 ppm, E= ND to 0.0006 ppm S/E Ratio=NA to 717
PCB	S=ND to 0.91 ppm, E=ND S/E Ration=NA	S=ND, E=ND S/E Ratio=NA

[1] ND=Not detected.

The ratios shown in Table 4a suggest a variation in the solubility of the analytes that have established ERL and ERM concentrations. Discussions with R. Gossett (pers. comm.) provided information on the expected sediment:elutriate concentrations for those analytes. Of the analytes listed in Table 4a, As and Cu would be expected to be most soluble, while the remaining contaminants' solubility would be expected to range from near zero to approximately 60%. The latter analytes would, therefore, be expected to adsorb onto the fine-grain sediments and eventually be re-deposited onto the sea floor. Data in Table 4a does, in some cases, support that expectation, however, the variability in sediment grain size in the shell mound material could account for the apparent discrepancies with Gossett's information.

5.2 BIOLOGICAL AND HABITAT CHARACTERIZATION

A total of 250 minutes of videotape and 95 underwater still photographs were taken during the two-day field survey on August 1 and 2, 2000. Video footage of 12,320 ft² (1,145 m²), comprising 1,722 ft² (160 m²) of sedimentary habitat and 10,598 ft² (985 m²) of shell and mixed shell/sediment habitat was recorded during the ROV survey. A 38-minute edited videotape was produced from the original footage. ROV transect lines are shown in Volume II, Appendix B, and Plates 6 through 10 are photographs of representative habitat types and biota observed during the ROV survey of the four shell mounds. Table 5 lists the area surveyed at each site by habitat type during the ROV survey.

Table 5
Area Surveyed by ROV Video for the Shell Mound Study, August 2000

Platform	Area of Sedimentary Habitat ft² (m²)	Area of Shell and Mixed Habitat ft² (m²)
Hazel	505 (47)	4,616 (429)
Hilda	463 (43)	1,879 (176)
Heidi	151 (14)	2,087 (194)
Hope	603 (56)	2,001 (186)
Total	**1,722 (160)**	**10,598 (985)**

5.2.1 Sedimentary Habitat

Similar to conditions reported in de Wit, 1999, the seafloor sediments around each shell mound comprises soft brown silt with occasional depressions and burrows. Sea pens, and cerianthid anemones dominate the macrobiota recorded within this habitat; flatfish were uncommon. Generally, the density of the cerianthid anemones increases around the perimeter of the shell mounds; sea pens are more abundant in the sedimentary habitat away from the shells. Table 6 lists the relative abundance of the macroepibiota recorded within the sedimentary habitat surveyed.

The densities of sea pens and cerianthid anemones recorded during the August 2000 ROV survey are approximately the same as those reported in de Wit, 1999 from a similar survey completed in October 1998. No commercially-important fish or invertebrate taxa were recorded within the sedimentary habitats during either of the surveys.

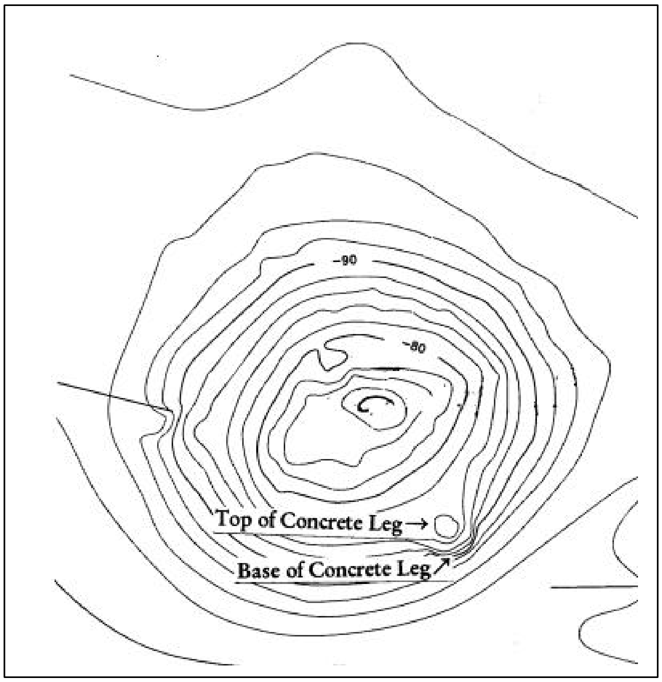
Table 6
Relative Abundance of Macroepibiota and Fish Observed on the Sedimentary Habitat Around Each Shell Mound Site
(Number of organisms per m²)

Species	Hazel	Hilda	Heidi	Hope
Sea pens	0.5	2.4	1.5	0.8
Cerianthid Anemones	0.5	2.0	2.7	0.4
Unid. Fish	<0.1	0.1	0.2	<0.1
Unid. Octopus	---	<0.1	---	---
Kelletia kelletii	---	---	<0.1	---
Asterina miniata	---	---	<0.1	<0.1

5.2.2 Shell Mound Habitats

The shell mound habitats comprise natural (shells and sediments) and man-made material (pipelines and concrete). The latter consists of inactive/abandoned oil and gas pipelines around the perimeter of the mounds and one exposed platform leg located near the southeast corner of the shell mound at the Platform *Hazel* site (see figure below).

Bathymetry of Platform *Hazel* Shell Mound and Location of Exposed Concrete Leg
Depths in Feet (MLLW)



That concrete leg extends approximately 12 ft (3.7 m) off the bottom and angling in slight northwesterly direction. The mounds are not perfectly conical, but comprise relatively steep sides with flat areas; approximately 50% of the mound area is mixture of sediment and shells. Depressions up to approximately five ft (1.5 m) deep were observed on the shell mounds; the surficial material at bottom of those depressions was usually a mixture of sediment and pieces of shells. A white “film” were observed at the bottom of two of these depressions (see Plate 10). The composition of that “film” is unknown, but is assumed to be bacteria.

Data shown in Table 7 show that the macroepibiota associated with the shell mounds is dominated by the bat star, *Asterina miniata*, while fish and the gorgonian coral *Lophogorgia chilensis* are more abundant around the exposed concrete leg. A solitary coral, *Coenocyathus* cf. *stearnsii*, was present to common on the exposed shells around the perimeter of the shell mounds.

The data in Table 7 indicates that the exposed concrete platform leg supports a similar epibiota and fish community as the shell areas, however, the relative density of gorgonian corals, sea stars, and most fish is higher there than in the surrounding shell habitat. The exposed portion of an abandoned pipeline near the perimeter of the *Hilda* shell mound supported several gorgonians; two subadult rockfish were also observed near that structure.

While the general species composition of the macroepibiota and fish associated with shell mounds is similar to that reported in de Wit, 1999, the relative abundance of juvenile and subadult rockfish and the bat star *Asterina miniata* has decreased over the past two years. Much of the exposed shell habitat is now covered with a thin veneer of fine sediment. Most of the gorgonian corals attached to the shells are small (0.5 ft in width and height) and few had exposed polyps. The filamentous white film observed at the Platform *Heidi* site was not reported in earlier surveys.

Table 7
Relative Abundance of Macroepibiota and Fish Observed on the Shell Mound and Man-Made Habitats at Each Site
(Number of organisms per m²)

Species	Hazel		Hilda	Heidi	Hope
Invertebrates					
	Shells/Mixed	Exposed Leg			
Asterina miniata	0.1	1.8	0.2	0.8	1.8
Cancer sp.	<0.1	---	---	---	---
Cerianthid anemones	0.2	---	0.1	<0.1	<0.1
Coenocyathus stearnsii	p[a]				
Corynactis californica	p on shells around exposed leg only	p to c	---	---	---
Cypraea spadicea	<0.1	---	<0.1	---	---
Kelletia kelletii	---	---	---	<0.1	---
Lophogorgia chilensis	<0.1	7.0	0.1	<0.1	<0.1
Muricea sp.	<0.1	1.5	---	---	---
Parastichopus spp.	<0.1	0.6	<0.1	<0.1	0.2
Pisaster brevispinus	---	0.3	---	---	<0.1
Pisaster giganteus	<0.1	---	---	<0.1	---
Sea pens (most common the around perimeter)	0.2	---	0.1	0.3	0.3
Unid. octopus	<0.1	---	<0.1	<0.1	<0.1
Unid. "bacteria film"	---	---	---	p[b]	
Fish					
Coryphopterus nicholsi	---	---	---	<0.1	<0.1
cf *Rathbunella* sp.	---	---	---	<0.1	
Sebastes auriculatus	<0.1	---	---	<0.1	<0.1
Sebastes spp.[c]	<0.1	0.3	<0.1	<0.1	<0.1
Zalembius rosaceus	<0.1	---	---	---	---
Unid. fish	<0.1	0.3	<0.1	<0.1	0.1

[a] P=present (estimated to be 1 to 5 individuals per m²), C=common (estimated to be more than 5 individuals per m²).
[b] White mat covering approximately 0.5m² (see Plate 10).
[c] Includes juvenile and subadult rockfish. Most common species was the calico rockfish, *Sebastes dalli*.

de Wit, 1999 summarizes the biota found on and around the shell mounds at various platform locations within the Santa Barbara Channel. References cited in that report, indicate that the shell mound community is an "extension" of that found on and around the platform structure, relying on the detached organic material to replenish the shell mounds. Historical studies indicate that fish and invertebrate communities around and on the shell mounds were diverse and rich, and included many species that have not been recorded since the platforms were removed. With the loss of the platform structures, the primary source of organic material, in the form of detached live mussels and other detritus, has been removed.

5.3 COMMERCIAL AND RECREATIONAL FISHING

5.3.1 Commercial Fishing

The California Department of Fish & Game (CDF&G) reports commercial marine fish catch and gear type(s) by Fish Block, a system of 10 minute latitude by 10 minute latitude areas. The four shell mound sites are within Fish Block 652 that extends along the coastline from west of Santa Barbara to Carpinteria and offshore approximately 5 miles. Water depths within that Fish Block range to approximately 160 ft (49 m). CDF&G-provided catch data from Fish

Block 652 for the most recent five years indicates that seven commercial gear types (seine, drift net, hook and line [including trolling], trawl, set net, trap, and diving) have been used within that area.

The data also provide annual catch data, by species code, for each block. Table 8 summarizes the total pounds caught by gear type, during the five-year period from 1995-1999.

Table 8
Commercial Fish Catch (Pounds) By Gear Type from CDF&G Fish Block 652
(1995-1999)

	1995	**1996**	**1997**	**1998**	**1999**	**Total**
Gear Type						
Seine[1]	118,409	10,411	88,347	25,282	0	242,449
Trap[2]	73,472	87,500	38,554	13,890	7,745	221,161
Dive	95,556	9,597	22,775	5,014	4,781	137,723
Trawl	3,560	4,171	3,713	14,174	22,943	48,561
Hook & Line[3]	13,830	1,607	1,767	1,380	886	19,470
Set Net	222	533	4,159	98	2,255	7,267
Drift Net	1,754	0	0	0	0	1,754
Unknown	173	0	0	14	48	235
Total	**233,107**	**113,915**	**159,315**	**59,849**	**38,661**	**678,620**

Source: California Dept. of Fish & Game, unpublished.
[1]Includes purse, lampara, and other seines.
[2]Includes fish, crab, and lobster traps.
[3]Includes set lines, trolling, longlines, and other hook and line types.

5.3.1.1 *Species Composition*: These data indicate that seines, targeting on pelagic species including sardines, mackerel, and anchovies, contributed the most pounds from the area for the five years depicted. Trap fishing for rock crab, spider crabs, and lobster contributed almost one-third of the total pounds for the period, while the dive fishery for urchins accounted for over 20% of the total. It should be noted that while seining contributed the largest percentage of the total pounds, almost half of that total was caught in a single year (1995), while the catch from traps and diving has decreased and the trawl catch has increased, particularly over the latest two years.

While seining is important in the area, the target species for that gear type are mobile, less dependent on substrate type, and widely distributed in the Santa Barbara Channel. Trap operations, particularly for crab and lobster, and trawling are more focused fisheries, usually targeting a relatively narrow range of water depths and substrate types. In the water depths in which the shell mounds are located, the surrounding sedimentary habitat would be more conducive to crabs than lobster, and for trawling for halibut, sea cucumbers, and ridgeback shrimp. It should be noted that the usual trawl depths for ridgeback shrimp range from 180 to 600 ft (55 to 183 m), well offshore of the shell mound sites.

Table 9 lists the eleven most abundant commercial taxa caught during the documented five-year period. The data in that table tends to support the gear type summary data discussed above: seine catches are large but irregular, urchin diving is relatively consistent in the area, and trapping of crabs and lobster contributed a substantial percentage of the total catch within Fish Block 652 during the period. Trawling inshore of the 3-mile limit within the Santa Barbara Channel is allowed, but is limited to halibut; all four shell mounds are located inside the 3-mile limit. Therefore, trawl operations in and around the four shell mounds target on halibut only; sea cucumber trawling could occur immediately offshore the two deeper shell mounds.

Table 9
Abundant Commercial Taxa from Fish Block 652[1]
1995-1999

	Total Pounds[2]	Years in Top Five	Gear Type(s) Used
Species			
Crab (unspecified)	104,908	95, 96, 97	Trap
Mackerel	101,860	95, 97	Seine
Sardine	97,500	95	Seine
Red urchins	64,052	95, 96, 97, 98, 99	Dive
Rock crabs	58,675	95, 96	Trap
Lobster	27,378	96, 97, 98, 99	Trap
Bonito	24,980	98	Seine
Ridgeback shrimp	20,130	99	Trawl
Anchovy	9,200	96	Seine
Spider crab	8,796	97, 98	Trap
Halibut	3,209	99	Set Net/Trawl/Unknown

[1]List comprises species/species groups that were one of the five most abundant during one or more of the years analyzed.
[2]Total pounds for the years in which the species/species group was in the top five.

Commercial fishing areas throughout California are summarized in MBC, 1989. According to that report and from information collected during interviews with commercial fishers, water depths usually targeted by commercial fishers for demersal (bottom-associated) species are: rock crab 60 to 240 ft (18 to 73 m), lobster 20 to 120 ft (6 to 37 m), ridgeback shrimp 180 to 540 ft (55 to 165 m), urchins to 100 ft (31 m), halibut 20 to 270 ft (6 to 82 m), and sea cucumbers from the 3-mile limit to 300 ft (91 m).

Discussions with C. Fusaro, pers. comm., corroborate these data. He stated that his understanding of commercial fishing around the shell mound areas comprises 1) trawling for halibut and sea cucumbers in the shallower waters, 2) trawling for ridgeback shrimp further offshore, and 3) crab and lobster trapping. Although not in the five most abundant taxa, sea cucumbers did contribute 5,425 pounds to the total for the period depicted in Table 8, and were recorded within the Fish Block for four of the five years listed. Urchin diving would be expected to occur around natural rock habitats and in water depths of 100 ft (31 m) or less.

5.3.1.2 *Historical Conflicts*: Mr. Fusaro also indicated that the area immediately around the shell mounds has been generally avoided by commercial trawlers since 1997. When the platforms were in-place, trawlers usually stayed 0.10 to 0.25 miles away; since the platforms have been removed, trawlers tend not to fish within 0.25 to 0.50 miles of the mounds.

Data from the Santa Barbara County Contingency Fund from June 1994 through January 2000 lists a total of 22 claims from commercial fishers. Two of those claims, both trawlers, one in August 1997 and the other in June 1998, were at one of the shell mound locations. C. Fusaro, pers. comm. indicated that he was aware of four conflicts between trawlers and the shell mounds within the last five years. He also stated that one Santa Barbara-based commercial trawler has not utilized the area around the shell mounds since 1997, about the time when the platforms were removed.

5.3.2 Recreational Fishing

McCrea, pers. comm. stated that he and other sport boat operators had used the platforms for half- and full-day sport fishing trips since the 1980s; historically, Platform *Hazel* had been one of the most "productive areas" for calico bass (=kelp bass, *Paralabrax clathratus*). Since the platforms have been removed, sport boat operators out of Sea Landing, a sport fishing operation in Santa Barbara Harbor, have only occasionally fished at the shell mounds where they target on sculpin and sandbass. McCrea also noted that when salmon are in the Santa Barbara Channel, they tend to concentrate around the areas where the shell mounds are located. He also indicated that the shell mounds are fished only when other sites have been less productive and the sport catch around the shell mounds usually consists of brown and calico rockfish. Most of the fish caught there have been relatively small individuals.

Diamond, pers. comm. supported McCrea's assessment of the shell mounds' limited recreational fishing value by stating that he utilizes the shell mounds only "once or twice a year" and the sport catch there is limited to sandbass and an occasional sculpin. He has also seen limited catches of croakers around the edge of the mounds. Diamond indicated that he has not seen any rockfish taken from the shell mounds since the platforms have been removed.

5.4 SEDIMENTATION AND SCOUR RATES

All four of the shell mound sites are in a low energy depositional environment within the mid-shelf mud zone. Sediment accumulation rates at all of the sites have been controlled by relative uplift and subsidence on either side of the Red Mountain fault, as well as the active Pitas Point fault to the south. The sites are located in structural depressions, or troughs, on either side of the Red Mountain fault. Sediments generally accumulate more rapidly in such structural depressions, creating depocenters.

Given the available data, the best method to estimate long-term sediment accumulation rates in the vicinity of the shell mounds is to divide the thickness of Holocene sediments overlying bedrock by the amount of time that has elapsed since the last sea level transgression (approximately 10,000 years). Fischer, 1972 mapped the distribution of Holocene sediment on the Santa Barbara Shelf using core hole data, while Hoyt, 1976 used high resolution profiles to estimate sediment thickness in the eastern Santa Barbara Channel. Fischer *et al.*, 1983 estimated the thickness of Quaternary shelf deposits in Southern California, and presented isopach maps of the eastern Santa Barbara Channel shelf. Although there are slight differences of the mapped thickness of Holocene sediments between the three studies, two broad areas of relatively thick Holocene sediments to the north and the south of the Red Mountain fault are documented.

Using data from Hoyt, 1976 the estimated sediment accumulation rate at the locations of former Platforms *Hazel* and *Hilda* is 0.04 to 0.06 in/year (0.9 to 1.4 mm/year), and the estimated sediment accumulation rate at the former Platform *Hope* and *Heidi* sites is 0.06 to 0.08 in/year (1.5 to 2.0 mm/year). Using data from Fischer *et al*., 1983, the estimated sediment accumulation rate at the former Platform *Hazel* and *Hilda* sites is 0.05 to 0.06 in/year (1.2 to 1.4 mm/year), and the estimated sediment accumulation rate at former Platforms *Hope* and *Heidi* is 0.07 to 0.08 in/year (1.8 to 2.0 mm/year). Thus, the range of estimated sediment accumulation rates at the former Platforms *Hazel* and *Hilda* sites is 0.04 to 0.06 in/year (0.9 to 1.4 mm/year), and ranges from 0.06 to 0.08 in/year (1.5 to 2.0 mm/year) at the former locations of Platforms *Hope* and *Heidi*. Sediment cover observed on the shell mounds during the most recent ROV survey of the sites tends to support these calculated depositional rates. The exposure of the concrete platform leg at the Platform *Hazel* site is likely due to settlement of the shells and the lack of continued shell material deposition since the removal of the platform.

No scouring was observed on or around the shell mounds. There is no bathymetric depression or "moat" around the mounds, as might be expected if significant scouring was taking place. Local scouring may occur on the western, up-current, side of the mounds during storm events, but the available evidence suggests that net sediment accumulation is taking place.

5.5 POTENTIAL METHODS OF REMOVAL

Considering the physical characteristics and the shape and slope of the shell mounds, the list of candidate removal methods consists of: dredging that includes scraping and excavating; trawling using Gorilla nets; and using shape charge explosives. Removal via explosives considers only the use of shaped charges placed at depth (*i.e.*, drilling holes into the shell mound) to break up the material, thus facilitating removal. The use of explosives would necessarily be followed by either scraping or excavation using one or more of the feasible removal techniques. As an alternative to removal, this analysis also describes containment by capping of the shell mounds.

Using the marine mining terminology and conventions of Cruickshank, 1992, there are four basic methods of offshore dredging: 1) scraping the surface; 2) excavating a pit (equivalent to a quarry on land); 3) tunneling beneath the seafloor; or 4) extracting the material through a bore hole or other conduit as a fluid (*i.e.*, fluidizing). For the purposes of this analysis, only scraping and excavation offer viable techniques for shell mound removal. In general, selection of an appropriate "mining system" depends on: 1) the ease with which the material may be excavated and removed from the surrounding environment; 2) the water depth; and 3) the ocean climate in the area of operations (Cruickshank *et al*., 1969, 1987). These techniques are described below. Additional detail is provided in the Continental Shelf Associates' report in Volume II, Appendix D.

5.5.1 Scraping

Scraping methods involve the removal of surficial material from the seafloor by traversing across the feature. Examples of scraping methods used in conventional shallow water systems are detailed below. Continental Shelf Associates, Inc., 1993 also describes tested and speculative deep water systems, neither of which are considered in this analysis.

Conventional shallow water systems include: 1) mechanical drag-line dredges, and 2) trailing suction hopper dredges, used for recovery of sand and gravel.

5.5.1.1 Dragline Dredge: These dredges are used in offshore mining and deep seabed sampling, as well as in marine construction. Their use has been advocated for the recovery of seabed nodules and slabs of phosphorites (Mero, 1965). Material would be recovered by large dredge buckets that scrape the surface of the deposit and then placing the recovered material into barges for transportation to shore (Figure 7).

A variation on the drag-line dredge, the Gorilla Net®, a heavy duty trawling net, has been employed for site clearance operations in the Gulf of Mexico (Figure 7a). Details of this technique are discussed in Section 5.5.3 below.

5.5.1.2 *Trailing Suction Hopper Dredge*: A suction hopper dredge uses a pump to draw a slurry of water and sediment into a riser or pipe leading to the vessel. As the sediment accumulates in the hopper, the water decants overboard. While this system has been used historically for maintaining harbor channels, it has also been used extensively for mining sand and gravel in water depths up to 120 ft (36 m) in the North and Baltic Seas (Padan, 1983; Nunny and Chillingworth, 1986). More recently, vessels (e.g., *ARCO Avon*, launched in 1986) have been designed to extend mining capability to depths of 150 ft (45 m) or more (Drinnan and Bliss, 1986).

As its name implies, the trailing suction hopper dredge mines while in motion, creating numerous shallow trenches in the seabed commonly about 3ft (1 m) wide and 1 ft (0.3 m) deep (Figure 8). This dredge uses one of several drag heads, each of which is equipped with a coarse-grid steel framework positioned across the opening of the suction head to prevent large rocks from entering the suction pipe. Coarse particle sizes are screened out and rejected after passing through the pump. Fine materials are washed overboard with the slurry overflow. In some cases, vibrating screens allow part of the sand fraction to be dumped back into the ocean because the ratio of sand to gravel recovered may differ from the desired marketable mix. Additional details on the equipment used are provided in Hess, 1971.

5.5.2 Excavating

Mineral deposits that are located predominantly within or under the seabed may be removed by excavation. These deposits include thick deposits of sands; metalliferous muds; layered or disseminated deposits of unconsolidated placer minerals or overlying bedrock; and deposits of consolidated minerals in vein, tabular, or massive form which may extend for considerable distances into the bedrock. The shell mounds could be considered similar to consolidated mineral deposits in massive form.

5.5.2.1 *Conventional Dredging*: Examples of conventional dredges operating from floating platforms include the clamshell bucket, bucket ladder dredge, bucket wheel suction dredge, stationary suction dredge, and cutterhead suction dredge. Each of these conventional dredges operates in a stationary or anchored mode.

Clamshell buckets (or clamshell hopper dredges) have been used to mine sand and gravel in the marine environment in several offshore locations. The buckets are mechanically actuated to "bite" into the seabed and remove material (Figure 9). The need for multiple cables to actuate the grabs can cause complications, particularly in heavy seas where wave-compensating devices may also be needed. Moreover, the clamshell is inefficient in clearing fine sediments overlying bedrock. It is best suited for excavation of large-size granular material where accuracy of positioning and cleanup is not important. The size of buckets range up to 10 yd^3 (7.6 m^3). A clamshell dredge is usually mounted on a barge that utilizes a multi-anchor system to secure its position. The bucket is lowered into the water with a crane, "grabs" the sediment to be excavated and is recovered to the surface. The material within the bucket is deposited into a barge or re-deposited onto the sea floor. The dredged material is stored on the barge until maximum capacity is reached when the barge is towed to the pre-selected disposal site.

The bucket ladder consists of a chain of connected buckets mounted over a digging arm or ladder. This system is most efficient for the excavation of deposits containing boulders, clay, and weathered bedrock. Dredges of this type have been used successfully worldwide for mining gold, platinum, and tin placers and diamond deposits, although their use offshore has been limited to gold and tin. Bucket ladder dredges are frequently used in harbors due to the ability to excavate broken rock and coral. The system delivers a virtually water-free product to the surface (*e.g.*, a mineral dressing plant aboard the dredge or storage barge). Considerable turbulence accompanies these operations. In addition, the bucket ladder dredge is limited to a maximum water depth of about 150 ft (45 m) and they are rarely used in water depths exceeding 65 ft (20 m). Few of these dredges have been built for offshore mining in the last several decades, and it is likely that they will be superseded by the bucket wheel suction dredge (Continental Shelf Associates, Inc., 1993).

Bucket wheel suction dredges use a small-diameter, wheel-mounted bucket on the suction ladder to excavate material. This system combines attributes of the bucket ladder and the suction dredge. Very high torque can be applied to the wheel, which delivers the excavated material directly into the mouth of a suction pipe for transport to the surface. Digging capability is equal to that of the bucket ladder, while the depth capability using submerged pumps is almost unlimited. The combination of simultaneous digging and removal at the seabed provides the option of either treating the material aboard the vessel or transporting it directly to shore.

Stationary or anchored suction dredges (Figure 10) are widely used in Japan for mining sand and gravel in water depths of 100 ft (30 m) or less and are being designed for use in water depths of up to 650 ft (200 m), Tsurasaki, *et al.*, 1988. These dredges have been used in Britain as well, although the vessels built since 1980 are almost all trailing suction dredges (Drinnan and Bliss, 1986). In contrast to the trenches left by trailing suction dredges, anchored suction dredges leave deep pits in the seabed.

Cutterhead suction dredges are used to excavate fairly compacted, granular materials in water less than 100 ft (30 m). The rotating cutterhead is usually an open basket with hardened teeth or cutting edges, with the end of the suction pipe located within the basket (Figure 11). In standard practice, the dredge is swung back and forth in an arc pivoted from a large post or spud attached to the stern of the dredge vessel. Cutterhead suction dredges may also be equipped with a multiblade ripper to cut into moderately consolidated rock. Suction dredges circulate large quantities of slurry that must be decanted onboard the dredge or pumped ashore by pipeline. In either case, there is a significant discharge of water containing fine particulate material.

5.5.2.2 *Submersible Systems*: Submersible systems include tracked suction dredges operating on the seafloor. Several such machines have been developed over the years for the excavation of nearshore sands for beach replenishment, for preparation of aquaculture beds, and for general oilfield excavation work. A schematic of this system is provided in the removal methods technical report in Appendix D, Volume II.

5.5.2.3 *Continuous Line Bucket*: The continuous line bucket (CLB) system consists of a series of drag line buckets operating in a continuous loop. The use of the CLB system for mining shallow deposits in coastal areas or sheltered waters has been proposed and may be encountered in the future, according to Masuda *et al*. (1991).

5.5.3 Trawling / Dredging

As noted previously, a variation on a standard scraping technique (*i.e.*, use of a dragline dredge) is the use of heavy-duty trawling nets. While not usually employed in seafloor mining, heavy-duty trawl nets have been frequently used in recent years to remove oilfield debris from abandoned offshore leases in the Gulf of Mexico (*i.e.*, for site clearance operations). Trawling operations are normally conducted in a "criss-cross" pattern over the lease, leaving a similar but more closely spaced pattern than that reflected in Figure 8. Trawling vessels with engines in the 600+ horsepower range are normally employed in such site clearance operations (J. Martin, pers. comm.). B-J Martin, Inc. developed the "Gorilla Net®"(Figure 7a) to more efficiently clear an area around a platform. The "Gorilla Net®", a patented trawl net, is constructed of heavy duty twine that has ten times the breaking strength of the regular trawl twine and could handle a much larger load that conventional nets.

B-J Martin, Inc. has had no prior experience with removing shell mounds. Operators in the Gulf of Mexico have reportedly used clamshell buckets or mechanical draglines to remove large concrete debris that could not be removed via the "Gorilla Net®"

5.5.4 Explosives

Deposits that are too hard to excavate by dredging must be broken by other means. One such system that is used for excavating hard-rock deposits is to drill into the deposit and use explosives to break solid substrata. Blasting of the material is an intermediate step and would be followed by removing the fractured material by one of the methods previously described. Shape-charge blasting operations are designed to expend as much force as possible on fragmenting the deposit.

5.5.5 Capping

Two capping procedures are presently applied in dredge disposal: 1) level bottom capping (LBC), and 2) contained aquatic disposal (CAD). These two types of underwater sediment disposal and capping are discussed and detailed in a recent environmental assessment prepared for the Puget Sound Confined Disposal Site Study (USACE, *et al*., 1999); summary information on these methods is provided below. LBC is the placement of contaminated material on a flat or gently-sloping seafloor and covering the material with uncontaminated sediments. The cap is designed to isolate the contaminated material from the marine environment, and to minimize the potential for contaminant migration through the capping material. Soft bottom benthic communities are typically reestablished on the capping material following final cap placement.

CAD is similar to LBC but includes some form of lateral confinement (*e.g.* placement in natural or excavated bottom depressions or elevated berms) to minimize spread of the materials on the bottom. CAD is generally used when the properties of the contaminated material or the surface or subsurface conditions (*e.g.* steeply-sloped or nearby groundwater) require lateral control measures to limit the spread of the contaminated sediments, USACE *et al*., 1999. Both LBC and CAD projects are routinely constructed in water depths of 100 ft (30 m), while successful LBC operations have been conducted as deep as 200 ft (61 m), Science Applications International Corporation, 1998.
Capping material is designed to physically isolate the contaminated sediments and comprises "clean" sediment capable of remaining in-place when subjected to prevailing currents at the site. Selection of the capping technique (surface or near-bottom discharge) necessarily considers minimizing resuspension of the contaminated sediments and the amount of material required to completely cover the site. The cap material is placed in layers over the contaminated material to a pre-determined thickness capable of precluding migration of the contaminants into the water column, and include consideration of bioturbation (excavation by infauna) effects.

Currents at the Platform *Hazel* site are expected to range up to 1 knot, therefore, cap sediments should be of sufficient size to remain in-place under those conditions. The cap material would be determined following detailed engineering design studies, and could include a mixture of sand and fine sediments capable of achieving the desired isolation of shell mound contaminants. Deposition of natural sediments (see Sedimentation and Erosion section, above) will add to the cap material and provide habitat for the infauna found within the area. Seafloor disturbance activities such as vessel anchoring and trawling could remove some of the capping material and should be restricted within the capped site.

5.5.6 Evaluation of Feasible Removal and Containment Techniques

Based on the summary of available removal and containment techniques presented above, a preliminary evaluation of each technique was completed and is presented in Table 10. Advantages and limitations for each technique are highlighted.

Based on the review of historical applications, depth limitations, and on the physical characteristics of the shell mound material, practical and viable approaches to shell mound site remediation techniques include:

- Clamshell bucket
- Trawling (Gorilla Net and Dragline)
- Sediment capping

Although relatively inexpensive, the Trawling methods could result in substantial turbidity within the water column due to the preponderance of fine sediments within all of the shell mounds. Further, these methods would, in essence, spread the shell mound material over adjacent natural seafloor habitat, thus increasing the seafloor disturbance. While clamshell bucket dredging is expected to also result in turbidity, that method is expected to be more efficient in recovering most of the sediments and reduce the amount of natural seafloor affected. Capping would be most effective at site(s) where contamination was found to be at concentrations that could result in toxic effects (Platform *Hazel*).

The relatively unconsolidated nature of the shell mound material suggests that blasting will not be required, however, concrete or steel debris may require removal by methods other than trawling or clamshell dredge. A summary of the three methods are provided below.

5.5.6.1 *Clamshell Bucket Dredge*: Although not documented for oil field debris clearance operations in state or federal Pacific offshore areas, sediment removal by this technique is common in open the ocean environment. The dredge barge would anchor over the targeted area, remove the material, and place the recovered debris into a barge tied-off to the dredge barge. Water collected during removal would decant over the side of the barge. Using the estimated volume of the shell mound material 7,000 to 14,000 yd^3 (5,352 to 10,704 m^3) per mound and a total of approximately 45,000 cy^3 (34,400 m^3), 700 to 1,400 buckets would be needed to remove the debris at each mound. Assuming 24-hour-a-day operations, 15 to 23 days would be required to remove the material from the four mounds.

Table 10
Comparison of Shell Mound Removal or Containment Techniques

Method	Depth Limits	Typical Use	Advantages[1]	Disadvantages[1]	Feasibility
Mechanical Dragline Dredge	Vessel and winch capabilities.	Deep sea mining, construction.	T=Simple operation. Low relative cost.	T=Lack of precision. E=Spread material over larger area. Potential for resuspension of fine sediments and contaminants.	Fair
Suction Hopper[2]	To 150 ft (45 m)	Sand and gravel mining.	T=Drag head variations. E=Reduced sediment resuspension	T=Untested for shell mound material. Lack of precision. E=Potential for sediment/water discharge from barge. Some sediment resuspension.	Poor
Clamshell Bucket[2]	Vessel and winch capabilities.	Offshore mining.	T=Simple operation., relatively low cost..	T=Lack of precision, seastate-limited. E=Lloss of some material during recovery to surface.	Good
Bucket Ladder[2]	To 65 ft (20 m)	Soft sediments to hard rock deposits.	T=Can remove large, irregularly-shaped material.	T=Depth limited. E=Resuspension of sediments.	Poor
Buck Wheel Suction[2]	None found.	Unconsolidated deposits.	T=Good digging power. E=Less resuspension of sediments.	T=Potential high cost. E=Water discharge from recovered material.	Good
Stationary Suction[2]	650 ft (200 m)	Unconsolidated deposits.	T=Removing sand and gravel deposits. Deep-water capability. E=Less resuspension of sediments.	T=Untested for shell mound material. E=Water discharge from recovered material.	Marginal due to unknown lift capability.
Cutterhead Suction[2]	To 100 ft (30 m)	Compacted and granular deposits.	T=Removing sand and gravel deposits. E=Less resuspension of sediments.	T=Depth limited. Untested for shell mound material. E=Substantial water discharge from recovered material.	Marginal due to unknown lift capability.
Submersible Systems	None found.	Unconsolidated deposits and oilfield debris.	T=Positioning accuracy. E=Limited resuspension of sediments at cutter head.	T=Potential high cost. E=Tracked equipment could leave temporary trenches around the site. Water discharge from recovered material.	Poor
Continuous Line Bucket[2]	Shallow water (mostly coastal/inshore)	Shallow deposits.	T=Limited digging power.	T=Limited number of operational systems available.	Poor
Gorilla Net	Limited only by vessel and winch capability.	Oilfield debris.	T=Simple operation. Relatively low cost.	T=Lack of precision. E= Spread material over larger area. Seafloor scars around the feature. Resuspension of sediments.	Fair
Shape Charges	Not applicable.	Platform legs, hard rock minerals.	T=Fractures larger material for removal by other means.	T=Requires drilling holes into material. E=Pressure and nose effects on biota. Requires removal of demolished material by other method.	Good (if needed)
Sediment Capping	To 200 ft (61 m)	Contaminated sediment containment.	T=Efficient. Precise location. E=Contains contaminateded material.	T=Requires several vessels. E=Large area outside shell mound affected.	Variable due to slope concerns and cap stability.

[1] E=environmental, T=technical [2]These methods may require anchoring, thus temporary seafloor scars could result.

5.5.6.2 *Trawling (Gorilla Net)*: Paired nets would be dragged across each mound to remove material capable of entering the net mouth. The mounds would be "flattened" and material too large for collection would likely remain on the seafloor for removal by other methods. The collected material would be loaded onto nearby barges and transported to shore or offshore for disposal. The number of trawls necessary to clear each mound would vary with the amount and size of material present. Assuming a 68-line grid across each mound and 12-hour a day operations, trawling would require from 40 to 60 days to remove the material from the four mounds.

5.5.6.3 *Capping*: Capping operations would commence with the collection and transport of the cap material to the site. The material would be deposited on the shell mounds (and surrounding seafloor) through either a bottom-dump barge or through a down-pipe (the later would provide a more direct deposit of the material onto the shell mound itself). The volume of material required would be determined through engineering design studies that would specify the slope angle required to maintain the material in-place. Assuming a 4 to 6% slope would be required, 611,505 to 1,432,386 yd^3 (467,581 to 1,045,260 m^3) of capping material would be required to cover the four mounds. The estimated time for capping operations ranges from 31 to 71 days for creation of a 6% and 4% slope, respectively.

If the material at one or more of the shell mounds is to be removed, the clamshell bucket dredge (with a sealed "environmental bucket") is likely to be the most efficient. Results of the sediment chemistry suggest potential water quality impacts and toxicity effects could occur from resuspension of the shell mound material during excavation. Capping is, therefore, possible if the cap material is placed in a manner that reduces resuspension.

5.6 AIR QUALITY

Short-term emission estimates for each of the feasible alternatives were similar to those found for the platform removal activities and were determined to be potentially significant. Table 11 lists the emission estimates for the three alternative removal methods under worse case condition, a 2.2 miles per hour (1 m/sec) southwest wind, the same worse case meteorological condition used in assessing platform removal emissions. Details on the calculation factors are provided in Volume II, Appendix D.

Table 11
Air Emissions from the Three Feasible Removal Methods

Alternative	Pollutant	Average Time	Emission (? g/m³)	Background[a] (? g/m³)	Total (? g/m³)	Standard (? g/m³)	Standard Violated
Clamshell	NO_2	1-hour	1,282[b]	28	396	470	No
	SO_2	1-hour	98	26	124	655	No
	SO_2	24-hour	39[c]	18	57	105	No
	CO	1-hour	542	5,221	5,763	23,000	No
	CO	8-hour	380[c]	2,889	3,268	10,000	No
	PM_{10}	24-hour	10	57	67	50	Yes
Gorilla Net	NO_2	1-hour	93[b]	28	121	470	No
	SO_2	1-hour	9	26	35	655	No
	SO_2	24-hour	4[c]	18	22	105	No
	CO	1-hour	31	5,221	5,282	23,000	No
	CO	8-hour	22[c]	2,889	2,911	10,000	No
	PM_{10}	24-hour	1	57	58	50	Yes
Capping	NO_2	1-hour	987[b]	28	367	470	No
	SO_2	1-hour	71	26	97	655	No
	SO_2	24-hour	28[c]	18	46	105	No
	CO	1-hour	470	5,221	5,691	23,000	No
	CO	8-hour	329[c]	2,889	3,218	10,000	No
	PM_{10}	24-hour	3	57	60	50	Yes

[a] Background conditions same as those used in platform removal modeling.
[b] NO_x is converted to NO_2 by the ozone limiting method.
[c] Multipliers used to convert one-hour averages to longer periods: 0.4 (SO_2 to 24-hour), 0.7 (CO to 8-hour) per APCD Guidelines.

6.0 ENVIRONMENTAL IMPACTS OF REMOVAL

6.1 WATER QUALITY

As was shown in the elutriate analyses discussed above, resuspension of the sediments within the shell mounds could be expected to result in higher levels of most of the analytes within the water column around the removal sites. The Stratum 2 sediments comprise both sand and finer grain material, including clays. Some contaminants within the shell mounds could be expected to adsorb to those finer sediments during resuspension and could remain in the water column for an extended period of time. Deposition of the sediment is dependent upon the current speed and direction at the time of removal. As part of their ongoing monitoring of the Goleta Sanitary District's ocean outfall, Brown and Caldwell, 1997 provides an overview of the currents within the Santa Barbara. That report describes the nearshore currents as predominantly westerly, although the gyre created within the Channel results in a complex regime of eddies, influenced to some extent by tidally- and wind-generated currents. Using 1996 current meter data from near-surface (20 ft [6 m]) and near-bottom (62 ft [19 m]), that document reported current speeds ranging up to 0.3 knots (17.3/cm/sec), but 50% of time, currents were 0.2 knots (7.9 cm/sec) or less. Although the Goleta Sanitation District current meter monitoring stations are approximately 15 miles west and in slightly shallower water than the shell mound sites, these data corroborate other data sources.

While it is not possible to determine what the concentration of the water column contaminants might be during removal, it is likely that removal activities will result in resuspension and subsequent deposition of the sediments and associated contaminants. Deposition would most commonly be expected to be to the west. Elutriate bioassays indicate toxicity to test organisms was experienced with Platform *Hazel* sediments. That suggests that water quality around that site could be degraded during removal activities. The fine sediments would also be expected to increase turbidity around each of the sites throughout removal activities. The duration of that turbidity plume will depend upon the current speed at the time of removal, with the finer-grained components, most common in Stratum 2 and the natural sediment, remaining in suspension for a longer period than the heavy shell, sand, and rock cuttings. Specific deposition distances could be determined with a plume dispersion model, a task not completed as part of this study.

Placing anchors on the seafloor will likely resuspend natural bottom sediments, slightly increasing turbidity immediately around the anchor sites. That impact is expected to be local and short-term. Minimizing the number of anchor drops and the vertical recovering of the anchors by an anchor-tending vessel will further reduce turbidity effects.

Although test methods could not definitively determine if contaminants are migrating through the shell mounds and into the surrounding water, capping could reduce or stop leaching. Capping of the shell mounds from a surface or near-surface discharge could also result in resuspension of the internal sediments and subsequent degraded water quality and increased turbidity. If capping is used at any of the sites, it is recommended that capping sediments be discharged at or near the bottom to reduce turbidity and resuspension of shell mound material. Near-bottom discharge would also provide greater control, reducing the amount of material required to cover the shell mound and decrease the amount of natural bottom affected. Monitoring the thickness and the chemical composition of the capping material would provide site-specific data on the efficacy of the cap to isolate contaminant migration.

6.2 AIR QUALITY

The results of the modeling indicate that particulate matter (PM_{10}) concentrations for all three alternatives could be expected to exceed the state standard of 50 micrograms/m^3. Santa Barbara County is already a non-attainment area for PM_{10} and therefore additional particulate emissions are seen as a potentially significant air quality impact, possibly necessitating mitigation during the removal period. Due to the number and size of the vessels needed for the clamshell dredge to remove the shell mounds, that alternative has the highest emissions of the three methods. The Gorilla net method has the lowest emissions, but still exceeds the state standard for PM_{10}.

6.3 BIOLOGICAL AND HABITAT

Based on the data collected during the August 2000 ROV survey, removal of the shell mound habitats would not have significant negative impacts on any sensitive or economically valuable biological resources. While it is possible that the shells provide habitat for cryptic biota, including small fish, octopus, and crabs, the decrease in the relative abundance of the more common taxa since the 1998 survey indicates that the value of the high-relief, solid substrate habitat is minimal. Comparing the 2000 data with that collected in 1998, it appears that most of the exposed shells are now covered with hydroids and sediment. Sedimentation analyses discussed above suggest that sedimentation of the shells will likely continue at between 0.04 and 0.08 inches per year (0.9 to 2.0 mm per year). In addition, "settling" of the shell mounds (maximum height appears to have decreased by as much as 12 ft (3.7 m) since October 1998) has exposed more mixed bottom habitat. These two factors suggest the amount of exposed shell material will decrease thus reducing available habitat to which epibiota could attach.

The exception to the decreased habitat value of the shell mounds since 1998 is the presence of the exposed concrete leg at Platform *Hazel* and an abandoned pipeline at the Platform *Hilda* site. These two features support a relatively rich and diverse epibiota compared to the surrounding shell habitat. While none of the organisms found on the leg or on or immediately around the pipeline are unique, removal of those structures would eliminate a relatively dense aggregation of gorgonian corals (platform leg) and likely displace the few rockfish that were observed around the pipeline. The removal of the shell mound material itself (estimated to be an average area of approximately 31,000 ft^2 [2,880 m^2]) and displacement of the associated biota is not considered to be a significant impact, despite the relatively small amount of natural high-relief, solid substrate within the area.

Capping of the shell mounds would create a completely sedimentary habitat, likely suitable for colonization by species found on the natural sedimentary seafloor that currently surround the mounds. Habitat value of that high relief, sedimentary substrate is not expected to be high, but would support epi- and infauna communities similar to that in the immediate vicinity.

Removal of the shell mounds and disturbance of the surrounding natural seafloor, including that impacted by anchors from construction vessels, will increase turbidity within the water column through resuspension of surficial and in-mound sediments. Elutriate bioassays of the shell mound material indicates significant elutriate toxicity could result from excavation and resuspension of sediments from at least one of the shell mounds. Impacts to the biota from offshore disposal of the excavated material is not known, however, due to the relatively high concentrations of several potentially toxic metals and organic compounds, negative effects could be occur around the dump site. It is questionable whether any of the material would be suitable for offshore disposal.

The effects of resuspension of the off-site sediments (*i.e.* during anchoring of vessels) are expected to be minimal, local, and relatively short-term. No hard bottom substrate is known to be within the anticipated anchor spread needed for any of the potential removal techniques, thus no impacts to that sensitive habitat or associated biota are expected.

6.4 COMMERCIAL AND RECREATIONAL FISHING

Fish Block 652 encompasses approximately 54 square nautical miles (nmi^2) (188 km^2) of ocean and includes water depths ranging from 0 to approximately 160 ft (49 m). Utilizing the "normal" depth range of trawl species shown above, areas available for the various demersal commercial fisheries within that fish block are:

- Crab (traps from 60 to 160 ft): 38.5 nmi^2
- Lobster (traps from 20 to 120 ft): 12.3 nmi^2
- Ridgeback shrimp: No trawling within 3-mile limit
- Halibut (trawl from 50 to 160 ft.): 31.5 nmi^2

The areas listed above do not include areas of natural rock such as the isolated high-relief features offshore Carpinteria that are considered untrawlable. Further, if the area of avoidance currently used by commercial trawlers (nominally a radius of 0.5 nmi each) is utilized, each shell mound effectively "removes" approximately 1.6 nmi^2 (includes the diameter of each mound and a 0.5 nmi radius extending from the edge of each mound) or a total of 6.4 nmi^2, approximately 20% of the available 31.5 nmi^2, of halibut trawling area within Fish Block 652.

Removing the shell mounds would likely require anchoring of construction vessels over and around each shell mound for extended periods, effectively precluding all commercial and recreational fishing from that area during removal operations. Assuming a 6:1 (anchor line to water depth) ratio and a four-point anchoring system, the area inside the anchor pattern would be approximately 0.1 nmi^2 at each site, with an additional 0.5 nmi^2 outside of the anchor locations expected to be avoided by commercial trawlers. With support vessels, it is expected that up to 1 nmi^2 around each mound, or 3% of the halibut trawl area within Fish Block 652, would be effectively removed from commercial halibut trawling for the duration of removal at each site.

If all four shell mounds were removed, an additional 6.4 nmi^2 of halibut trawling area would be available to commercial fishers. With contaminated sediments evident at the *Hazel* shell mound, there is a possibility that that mound could be capped. If only three mounds are removed, the additional trawling area would be reduced to 4.8 nmi^2. The impacts of the preclusion area during removal operations is considered relatively short term, ranging from approximately 10 to 30 days per site. If capping is proposed for one site and removal for the others, it is possible that areas around two sites could be precluded simultaneously. The availability of an additional 6.4 nmi^2, or 4.8 nmi^2 to halibut trawling following removal is also considered a significant, beneficial impact to that fishery. If the ends of the pipelines remain uncovered, they present a potential snag to bottom trawlers; the pipelines themselves should not have any negative impacts to that fishing gear. Since crab traps are currently set in the area and lobster fishing is probably focused inshore of the shell mounds, no significant increase in available area for those fisheries is expected to result from removal. Short term increases in turbidity around the removal operations could result in local, insignificant impacts to demersal and pelagic species. Turbidity-associated impacts would include reduced light penetration, burial of benthic organisms, and avoidance of turbid water by the mobile species. These impacts are considered relatively short term and local in nature.

Video and still photographs of the shell mounds show them to be relatively steeply-sloped and, based on previous attempts at site clearance, untrawlable in their present configuration. In addition to the surficial shell material, near-surface concrete debris and the aforementioned exposed platform leg at the *Hazel* site, exacerbate the potential damage to trawl gear. Reducing the height and removing large metallic and non-metallic debris from the mounds could allow for trawlers to utilize the site, however, "knocking the mounds down" would likely increase the area of seafloor with shell debris. Commercial fishers would be expected to avoid areas of shell debris as it would likely foul nets, resulting in damage or loss of the gear. Even with "complete" removal of debris from the mounds and smoothing of the contours, the area is likely to remain untrawlable.

Trawling within the areas previously covered by the shell mounds will subject the habitat to disturbances similar to those that have occurred and are occurring within the natural bottom areas of the Fish Block. Although no documentation of the impacts of trawling have on the sedimentary habitat or associated biota within Santa Barbara are known, several studies on trawling effects have been completed in other areas. Brown, *et al.*, 1998 summarizes research on bycatch, ghost fishing, and physical impacts of various types of commercial fishing. Other relevant reports include Auster, 1998; Auster, *et al.*, 1995; Leth and Kuijpers, 1996; and Ball and Tuck, 2000.

Summarizing several earlier studies, Brown, *et al.*, 1998 states that bottom trawling can 1) disturb sediments, rocks, and other substrates, 2) increase near-bottom water column nutrient levels and reduce dissolved oxygen concentrations by resuspending nutrient-laden and anoxic sediments on the continental shelf, and 3) be the most common source of seafloor disturbance in deeper water where storm waves have little effect. Brown's report suggests that studies in New England and Alaskan waters have shown that trawling can reduce habitat structure and complexity by removing slow-moving or attached organisms and smoothing the sea floor. The authors also indicate there is growing evidence that "…intact bottom structure is important to temperate fishes, particularly during their early bottom-dwelling phases". Auster, 1998 is developing a mathematical model that assesses and allows comparison of the changes in habitat values in areas where no trawling has occurred with those in areas subjected to bottom fishing disturbances. Auster and Langton, 1999 found that recovery of the habitat after fishing was variable, depending upon habitat type, the life history of component species, and the natural disturbance regime.

Leth and Kuijpers, 1996 found the character of the natural sediments in the southern portion of the Danish North Sea was found to change from a relatively coarse sand and gravel material to fine sand and silt where beam trawling had occurred. The "tracks" left by the beam trawls apparently filled-in with the finer sediments that were normally removed by the prevailing currents. These changes were found to last for more than one year and resulted in an associated change in benthic community. Auster, *et al.*, 1995 also suggest that the sea floor habitat is less complex in areas where mobile fishing gear is used. The reduced complexity is associated with the removal of emergent epifauna and shells, and the smoothing of natural depressions and "biogenic depressions".

During the ROV survey of the shell mounds and surrounding natural bottom, we found no evidence of trawling or other commercial fishing-related sea floor disturbance. It should be pointed out, however, that our survey concentrated on and immediately around the shell mounds, areas where trawling is not expected. Data provided above indicate that commercial trawling likely occurs throughout the area around the shell mounds and, if removed, would occur at the shell mound sites, as commercial taxa in the surrounding sedimentary habitat are expected to inhabit the shell mound sites following mound removal. Sea floor disturbance at the shell mound sites would, therefore, be expected to be similar to that found in the area that is currently trawled.

Since commercial trawling has occurred within the area even before the platforms were constructed, and no pre-trawling infauna sampling is known, it is problematic to attempt to assess the significance of the impacts of trawling on the habitat and benthos of the area. Previous studies in similar sedimentary habitats have, however, shown that trawling does alter the sea floor and reduces habitat complexity. Once trawling occurs within the shell mound sites, those impacts could be expected. While the "newly available" sea floor represents approximately 20% of the available trawling area within the Fish Block, precluding trawling within that area could provide opportunities to study site-specific effects of trawling by comparing sediment characteristics, and epibiota and infauna communities within the areas to those in where trawling is occurs.

The removal is not considered a significant impact to recreational fishing.

7.0 ***ENVIRONMENTAL IMPACTS OF NON-REMOVAL***

7.1 WATER QUALITY

No water column sampling was conducted during this study, therefore it is not possible to assess existing water quality immediately around the shell mounds. While upward vertical migration of some of the contaminants is possible, the concentrations of those chemicals in the surrounding water are unknown.

7.2 AIR QUALITY

Although no site-specific data is available, no air quality impacts are anticipated from the shell mounds being allowed to remain in-place.

7.3 BIOLOGICAL AND HABITAT

Allowing the shell mounds, exposed platform leg, and nearby abandoned pipelines to remain in-place is not expected to have significant beneficial affect on the biological resources associated with those structures, except for the continued provision of suitable attachment substrate for gorgonian corals. While these structures do not appear to support any sensitive or economically-important taxa, they do provided limited-value solid substrate that is not common at these depths within the area. With the continued presence of the shell mounds, the epibiota and fish communities would be expected to comprise similar taxa as that reported previously. However, the relative abundance of those species would be expected to either remain unchanged or decrease over time as the shells are covered with sediment. The area of exposed clean shells (*i.e.* with little or no sediment cover) is expected to continue to decrease, thus reducing the amount of habitat available for epibiota attachment.

If the shell mounds are to remain in-place, enhancement of the existing habitat value through the addition of additional solid structure is possible. The relatively diverse biological community associated with the exposed portion of a concrete platform leg at the *Hazel* site and pipeline at the *Hilda* site indicates that those solid substrates provide habitat that is conducive to epibiota attachment. From a biological perspective, an increased habitat value could be achieved through the placement of additional solid substrate that would extend above the existing shell material. That substrate, comprising materials such as rock and upright concrete pilings would provide additional high-relief solid substrate for epibiota, which in-turn could support a relatively diverse fish community.

7.4 COMMERCIAL AND RECREATIONAL FISHING

The benefits to commercial and recreational fishing by leaving the shell mounds in-place appear to limited. The area precluded from commercial halibut trawling within Fish Block 652 would remain the same, assuming trawlers would continue to avoid the shell mounds by at least 0.25 miles. The continued preclusion of the estimated 6.4 nmi^2 from commercial halibut trawling is considered a significant loss of available area, particularly since the shall mounds appear, with the possible exception of crab and some rockfish, to provide limited value as a nursery area for other important commercial taxa.

Recreational fishing does not appear to be particularly productive around the shell mounds, although the habitat does appear to provide some sport fishing opportunities. The continued presence of the shell mounds would have limited benefits to the recreational fishery.

8.0 SUMMARY OF FINDINGS

Physical Characteristics

- Analysis of the cores indicate that the shell mounds at all four sites had similar physical characteristics, comprising three relatively distinct strata: 1) an upper layer of shell hash, 2) an intermediate layer of drill cuttings and fluids (muds), and 3) the underlying "native" seafloor sediments (marine shelf deposits).

- Stratum 1 was typically one to two ft (0.3 to 0.6 m) thick near the apex of the mounds and increased in thickness on the sides and near the base of the mounds. There was an oily sheen at the base of some of the Stratum 1 samples.

- Layers within Stratum 2 were typically 0.2 to 0.5 ft (<0.1 to 0.2 m) thick, but in some cases several feet thick, comprising a mixture of siltstone rock fragments, clay and fine sand, fine- to coarse-grained sand, and fine-grained sediments. The siltstone appears to be cuttings, while the finer sediments are likely a combination of drilling mud and material developed during the drilling process. An oily sheen and petroleum odor were present in several of the layers, being most obvious in the medium- to coarse-grain sand lenses.

- Stratum 3 was the natural seafloor sediment comprising layers of olive gray, medium-stiff clays with numerous small shells and shell fragments.

- Based on historical geological surveys, the range of estimated sediment accumulation rates at the former Platforms *Hazel* and *Hilda* sites is 0.4 to 0.6 inches per year and ranges from 0.06 to 0.08 inches per year at the former locations of Platforms *Hope* and *Heidi*. No scouring was observed on or around the shell mounds.

Chemical Characteristics

- The Effects Range Median concentration for Nickel was exceeded in the Strata 1 and 2 sediments at one or more sites and for PCB in Stratum 1 at one site.

- The highest concentrations of all heavy metals, Total Recoverable Petroleum Hydrocarbons (TRPH), and Polynuclear Aromatic Hydrocarbons (PAH) in all of the strata, including the natural sediments underlying the shell mound material, exceeded that in the reference site sediments.

- Stratum 1 sediments had the highest concentration of 12 of the 30 analytes, including eight that have established Effects Range Low (ERL) concentrations. Stratum 2 sediments had the highest concentration of nine analytes, three of which have established ERLs. Natural sediments had the highest concentration for six analytes, none of which have established ERLs. Three analytes were not detected in any of the strata sediments.

- Highest elutriate concentrations from reference sediment were less than or equal to shell mound strata concentrations for all analytes except for Arsenic, Iron, Mercury, Titanium, phthalates, and oil and grease.

- The results of the elutriate bioassay testing indicated that only the shell mound material at the Platform *Hazel* site was toxic to the test organism, a mysid shrimp, *Mysidopsis bahia*. The 96 hour Lethal Concentration resulting in 50% mortality (LC_{50}) was 48.57%. The LC_{50} for the other three sites exceeded 100%, indicating the maximum elutriate concentration was not toxic to the test organism at maximum concentration.

Biology and Habitat Value

- The macroepibiota associated with the shell mounds is dominated by the bat star, *Asterina miniata*, while fish and the gorgonian coral *Lophogorgia chilensis* are more abundant around an exposed concrete leg at the Platform *Hazel* site and near an exposed pipeline at the Platform *Hilda* site.

- Much of the exposed shell habitat is now covered with a thin veneer of fine sediment. Most of the gorgonian corals attached to the shells are small (0.5 ft in width and height) and few had exposed polyps.

- The general species composition of macroepibiota and fish associated with shell mounds is similar to that reported in a study completed in 1998, although the relative abundance of juvenile and subadult rockfish and the bat star *Asterina miniata* has decreased over the past two years.

Commercial and Recreational Fishing

- Commercial fishing data from Fish Block 652, which includes all four sites, indicate that seines, targeting on pelagic species including sardines, mackerel, and anchovies, contributed the most pounds from the area for the most recent five years. Trap fishing for rock crab, spider crabs, and lobster contributed almost one-third of the total pounds for that period, while the dive fishery for urchins accounted for over 20% of the total.

- Data from the Santa Barbara County Contingency Fund from June 1994 through January 2000 lists a total of 22 claims from commercial fishers. Two of those claims, both trawlers, one in August 1997 and the other in June 1998, were at one of the shell mound locations.

- Since the platforms have been removed, sport boat operators out of a sport fishing operation in Santa Barbara Harbor, have only occasionally fished at the shell mounds where they target on sculpin and sandbass.

Removal Options

- Clamshell or bucket dredging appears to be a feasible method of removal although resuspension of the contaminated materials are possible. This method could take from 15 to 23 days to remove the 45,000 yd^3 at the four mounds.

- Trawling, using a Gorilla-type net or dragline dredge, is also considered to be feasible but could also result in resuspension of contaminated materials, and would effectively spread the shell mound material over a larger area. This method is expected to take from 40 to 60 days to remove the material in the four mounds. Large material is not expected to be easily removed by trawling and would require supplemental equipment.

- Depending upon the final slope required, capping of the mounds could isolate the contaminated material and reduce leaching. It is estimated that from 611,505 to 1,432,386 yd^3 would be required to cover the four mounds and that some capping material would necessarily extend onto the natural seafloor beyond the shell mounds. Capping is expected to take from approximately 41 to 71 days to complete.

Impacts of Removal and Capping

- The major water quality impact of removal would be from the resuspension of contaminated. Elutriate toxicity of the material in the Platform *Hazel* shell mound was found, and the relatively high concentrations of heavy metals and organics in all of the shell mounds could degrade the water quality during removal. Short-term turbidity-related impacts are expected to occur during anchoring of construction vessels. Potentially significant water quality degradation, and associated toxicity to planktonic organisms, could be expected during removal operations at Platform *Hazel*. Turbidity effects are expected to occur throughout removal operations at all shell mounds, however, based on the elutriate testing, no water-column toxicity effects are anticipated from three of the sites. Some petroleum could be released during excavation of Strata 2, resulting in the potential for an oily sheen to appear on the sea surface.

- The shell mound-associated biota appears to have decreased in species richness and abundance since the removal of the platforms; the biological value of the shell mound habitat is relatively low. Removal of the shell mounds is not expected to result in the loss of any significant or unique biological resources. Capping will result in the creation of a high-relief, sedimentary habitat that is expected to support epi- and infauna similar to that found on and in the natural seafloor surrounding the shell mounds. Habitat value is not expected to be improved with the deposition of cap and natural sediments.

- The removal of three or four shell mounds will result in an additional 4.8 (16.7 km^2) to 6.4 square nautical miles (22.3 km^2) of halibut trawling area, respectively. The epibiota and infauna within that area will be subjected to trawl-related impacts similar to those in areas currently trawled. Those impacts include habitat alteration and damage or removal of the biota, as well as local turbidity increases and the potential resuspension of contaminated sediments. The impacts of the preclusion area during removal operations is considered relatively short term, but significant. The loss of the shell mounds is not considered significant to the recreational fishing industry. Capping will likely result in the continued loss of trawling area as fishers would not be expected to trawl over the sediment-capped features.

- PM_{10} emissions for the three feasible alternatives are expected to exceed the state standard under worse case conditions. Removal by clamshell dredge results in the highest air emissions of the three methods assessed.

Impacts of Non-Removal

- It is not known whether the water quality around and immediately above the shell mounds is being degraded, although, compared to reference sediments, the natural sediments underlying the shell mounds show elevated concentrations of some heavy metals and organics. Exposure of Stratum 2 sediments from the continued sloughing of shell material could, however, result in leaching of the contaminants within that strata into the surrounding water column.

- Neither commercial nor recreational fishing are expected to benefit from the continued existence of the shell mounds. The mounds provide no high-value habitat for commercial or recreational species and the continued avoidance of the mounds by commercial fishers results in the loss of potentially available areas for trawling.

- No air quality impacts are anticipated from the shell mounds remaining in-place.

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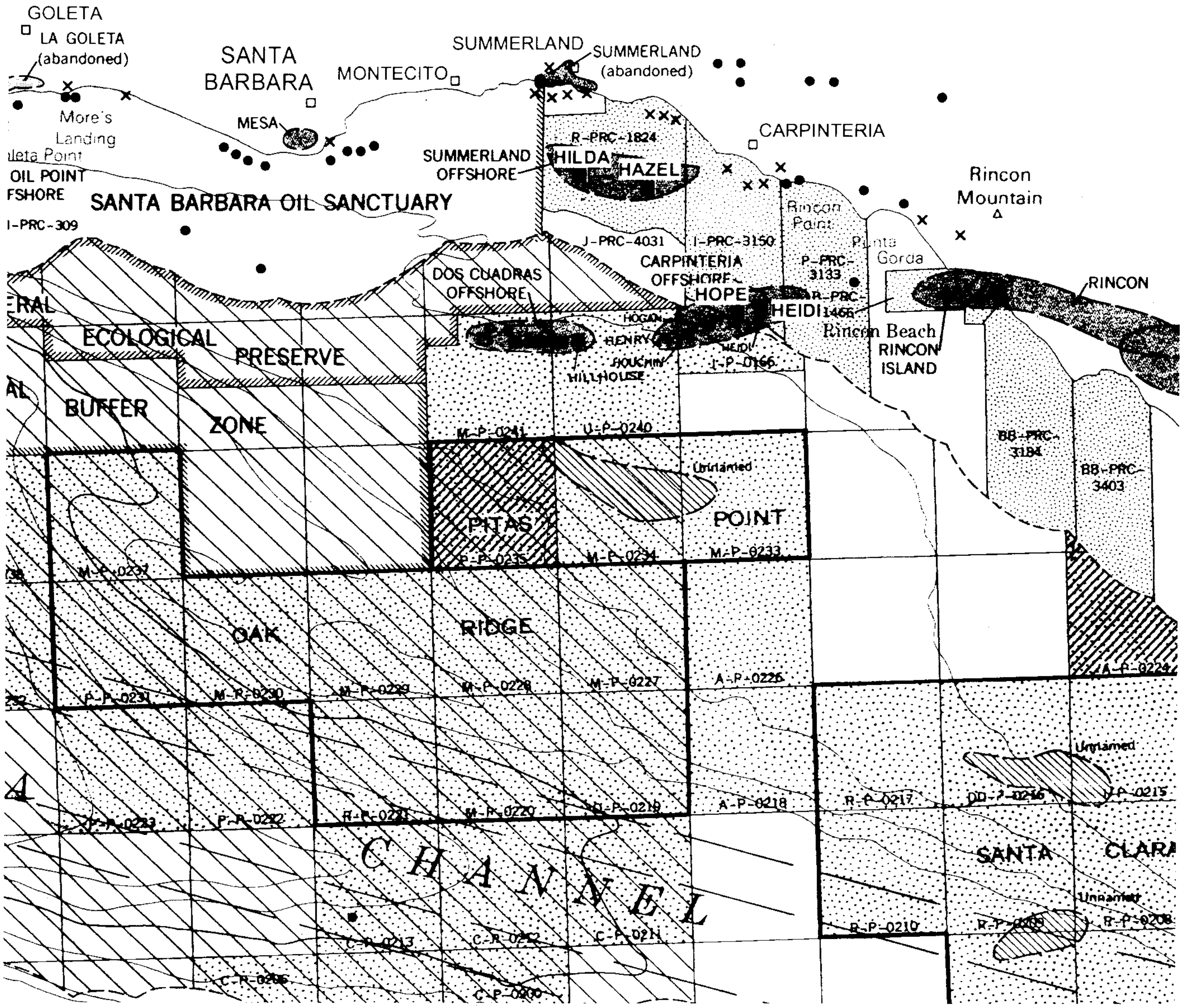
Figures and Plates



BASE MAP SOURCE: USGS 1:250,000 Map Showing Oil and Gas Fields, Leased Areas, and Seeps in the Santa Barbara Channel Region (Revised May, 1974).

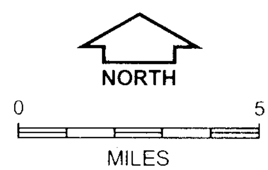


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FIGURE 1
VICINITY AND SITE MAP

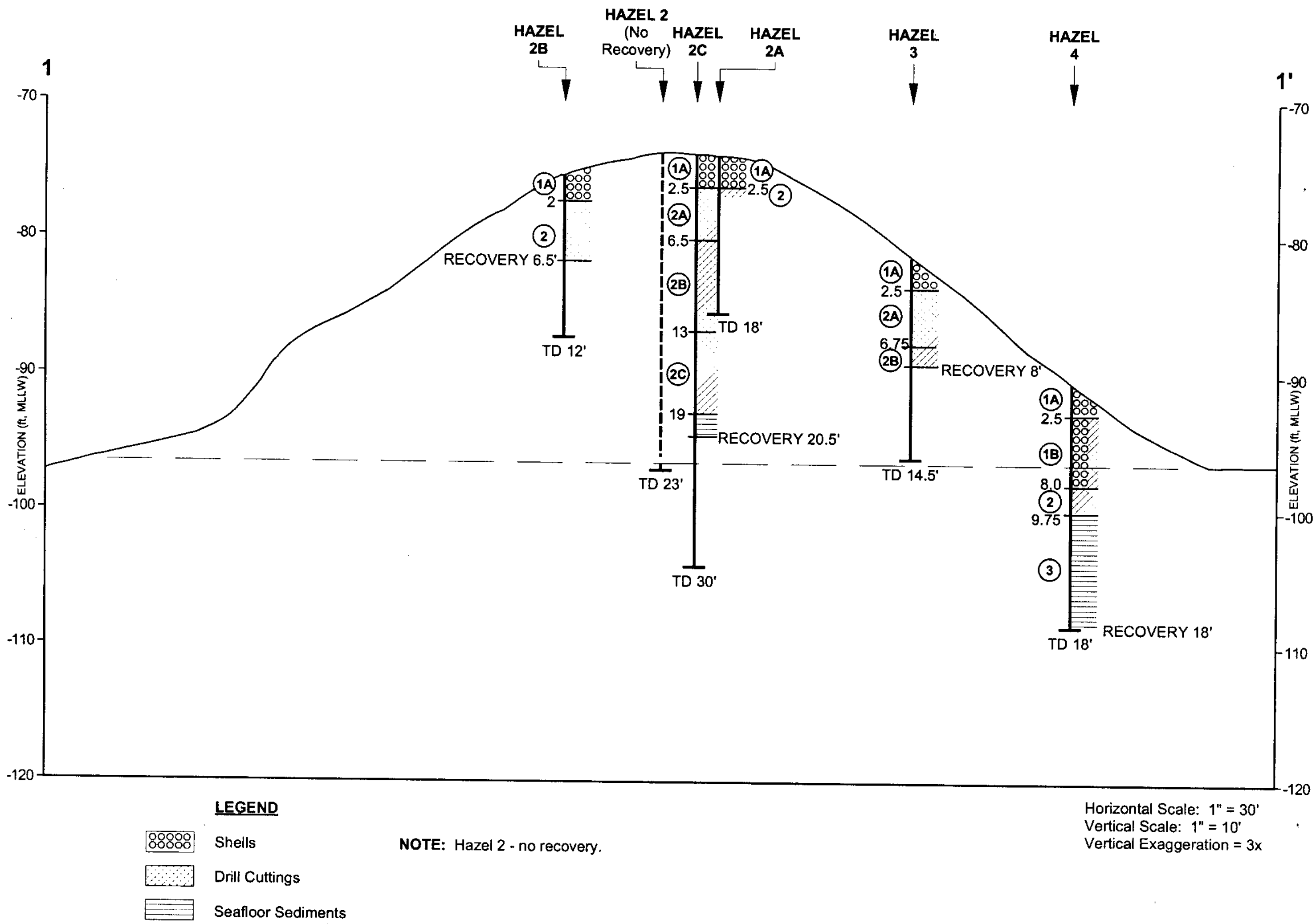

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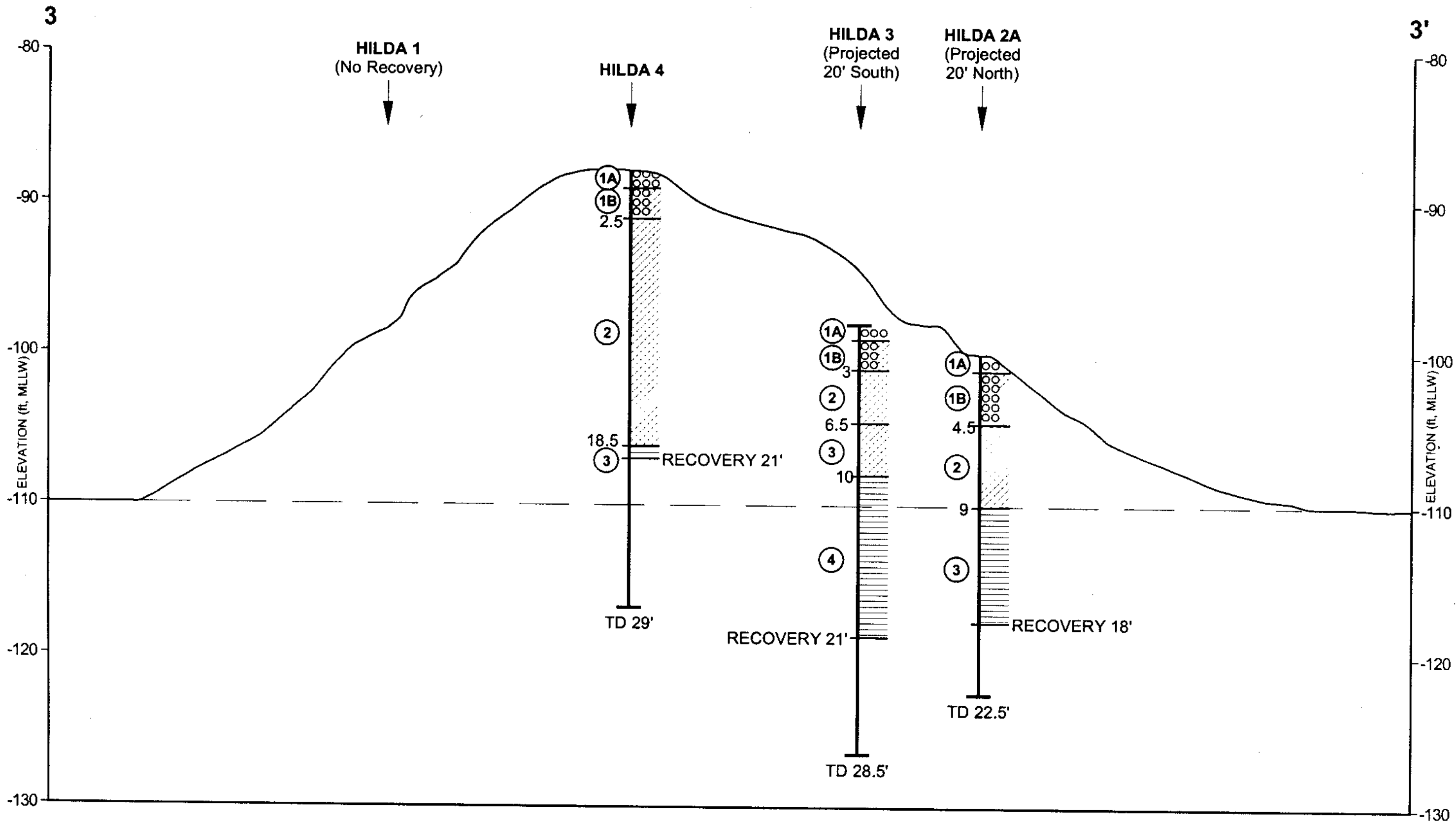
FIGURE 2
CROSS SECTION OF HAZEL SHELL MOUND



LEGEND

Shells

Drill Cuttings

Seafloor Sediments

NOTE: Hilda 1 - no recovery.

Horizontal Scale: 1" = 30'
Vertical Scale: 1" = 10'
Vertical Exaggeration = 3x

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FIGURE 3
CROSS SECTION OF HILDA SHELL MOUND

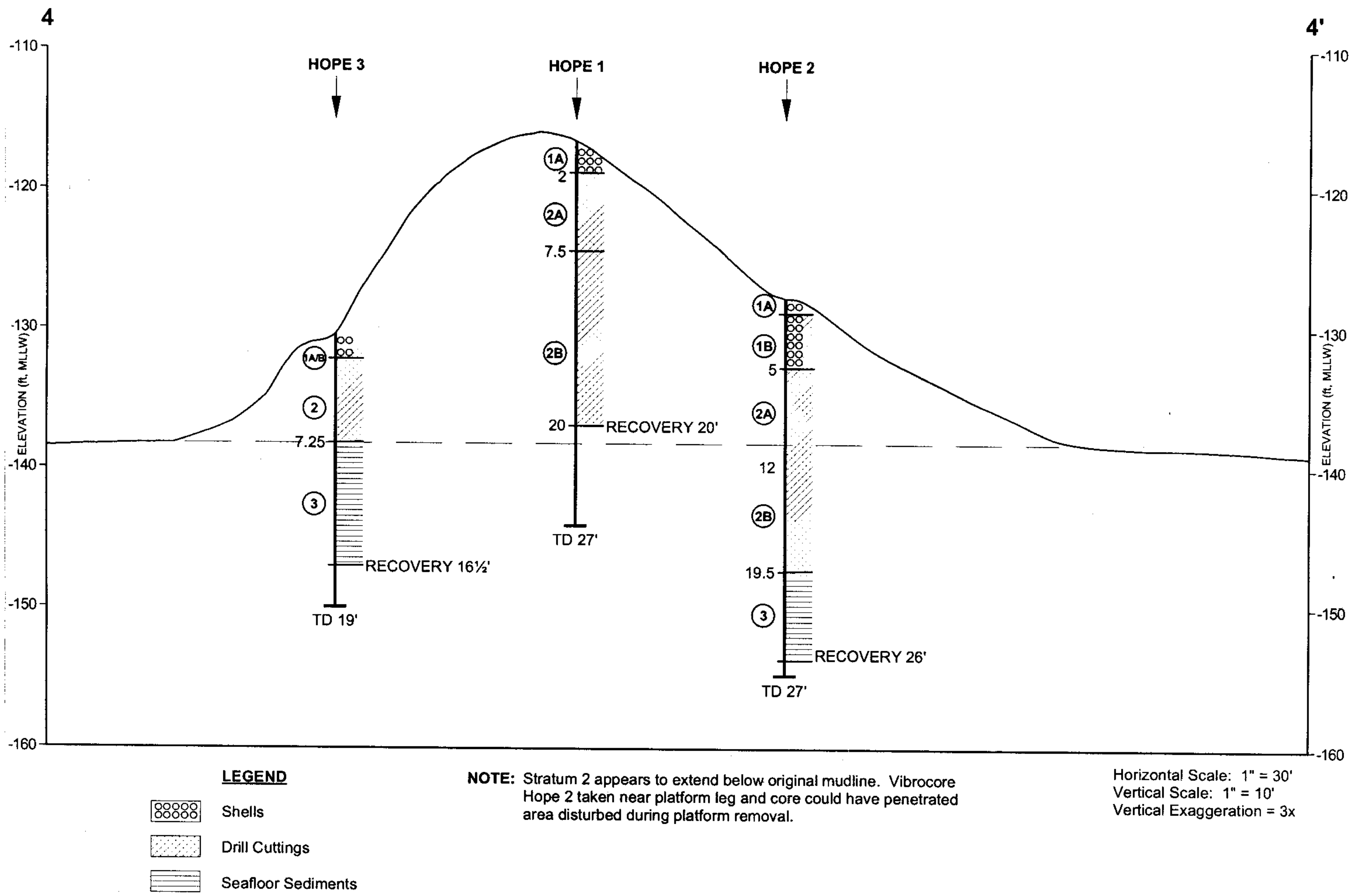

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FIGURE 4
CROSS SECTION OF HOPE SHELL MOUND

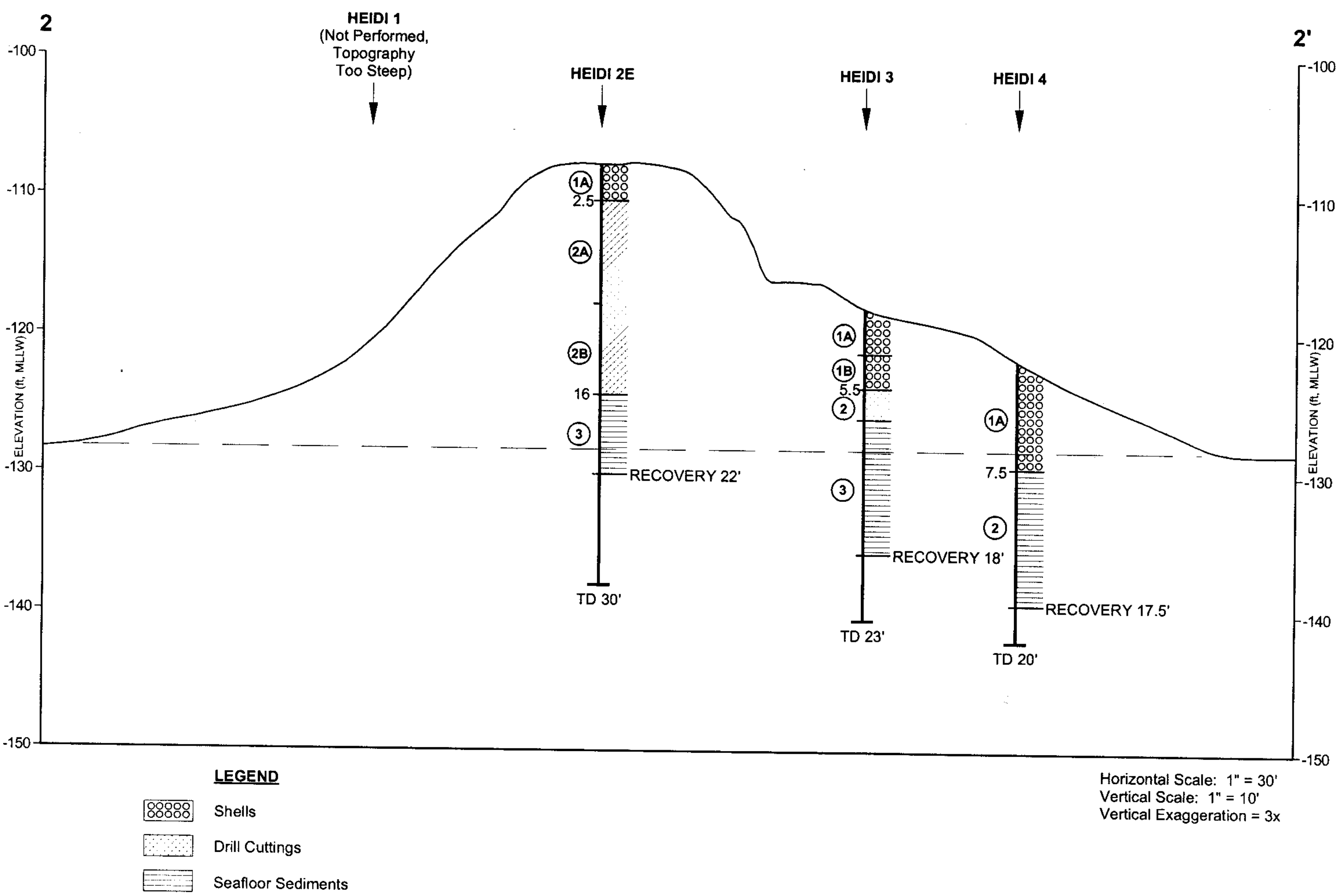

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FIGURE 5
CROSS SECTION OF HEIDI SHELL MOUND

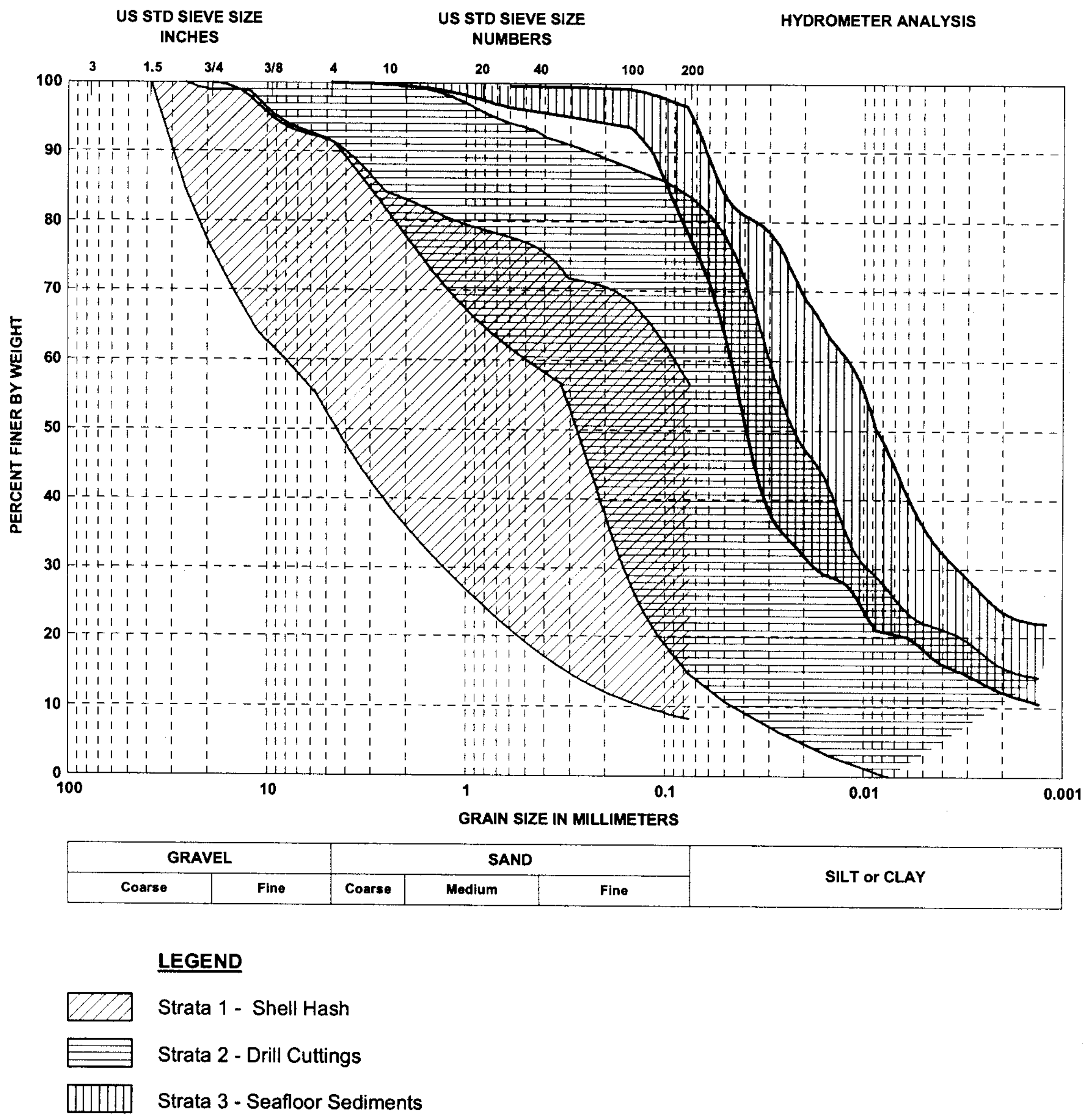

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FIGURE 6
COMPOSITE GRAIN SIZE CURVES OF THE FOUR SHELL MOUNDS

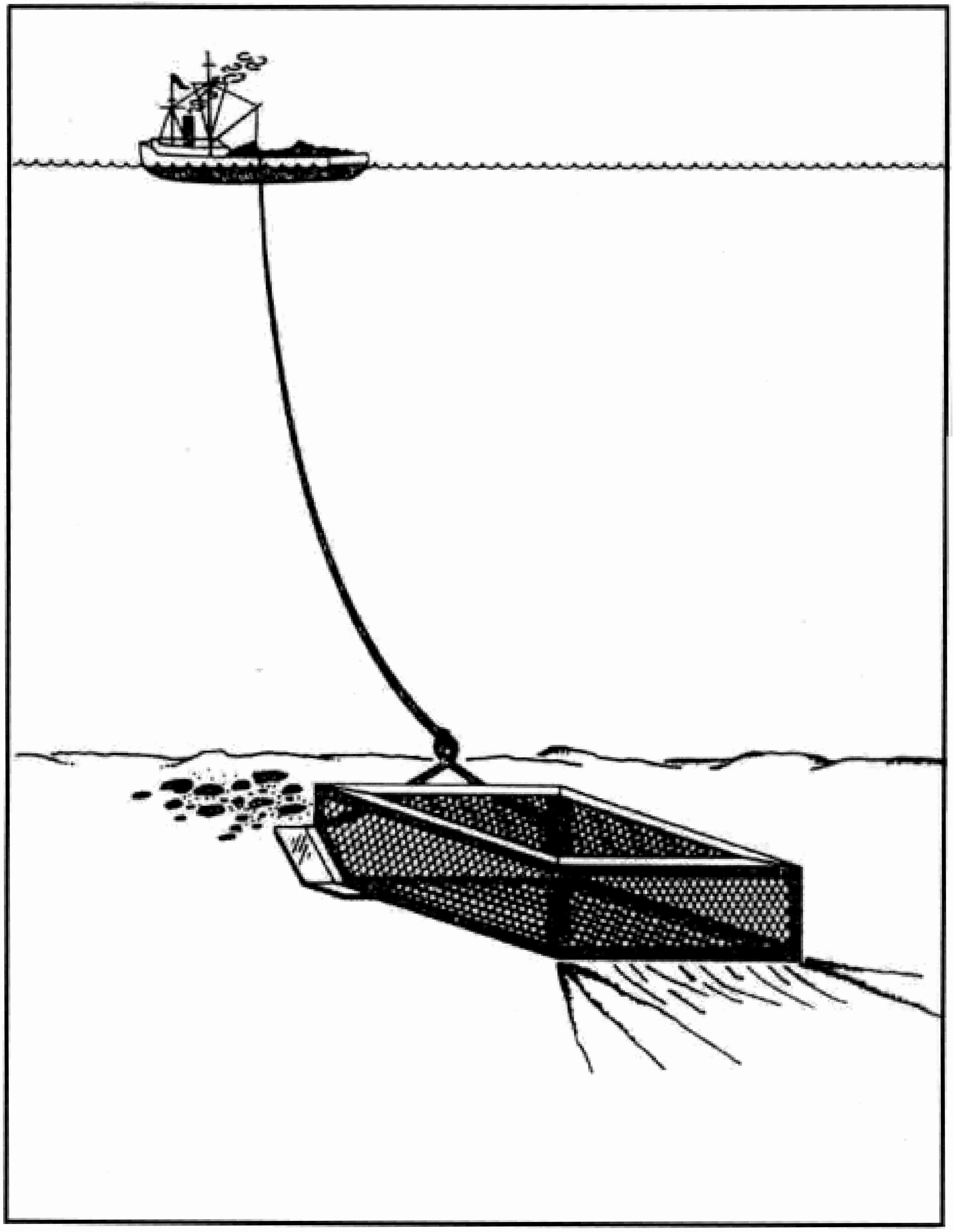

FIGURE 7
DRAGLINE DREDGE CONFIGURATION

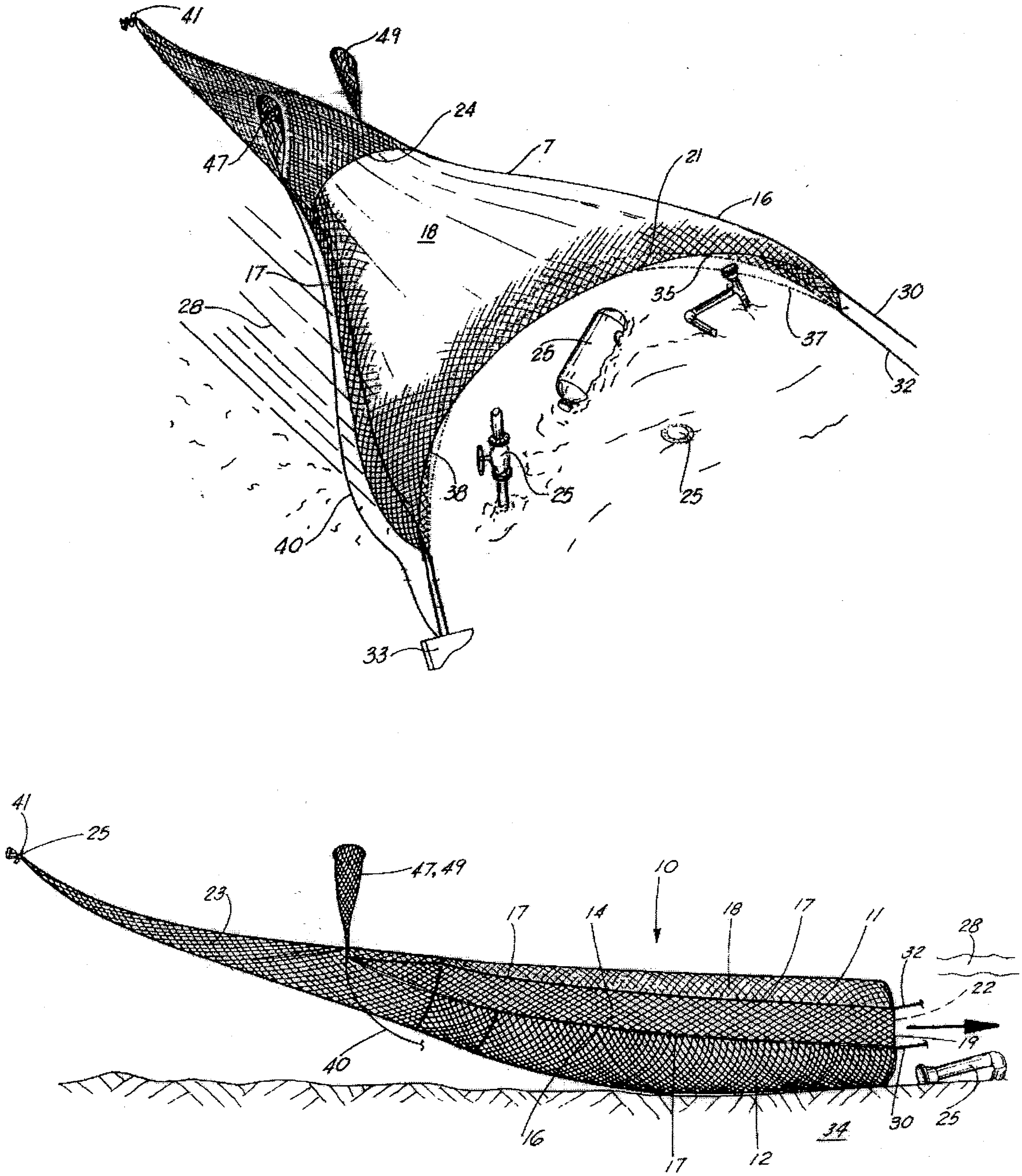

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FIGURE 7a
GORILLA NET® CONFIGURATION

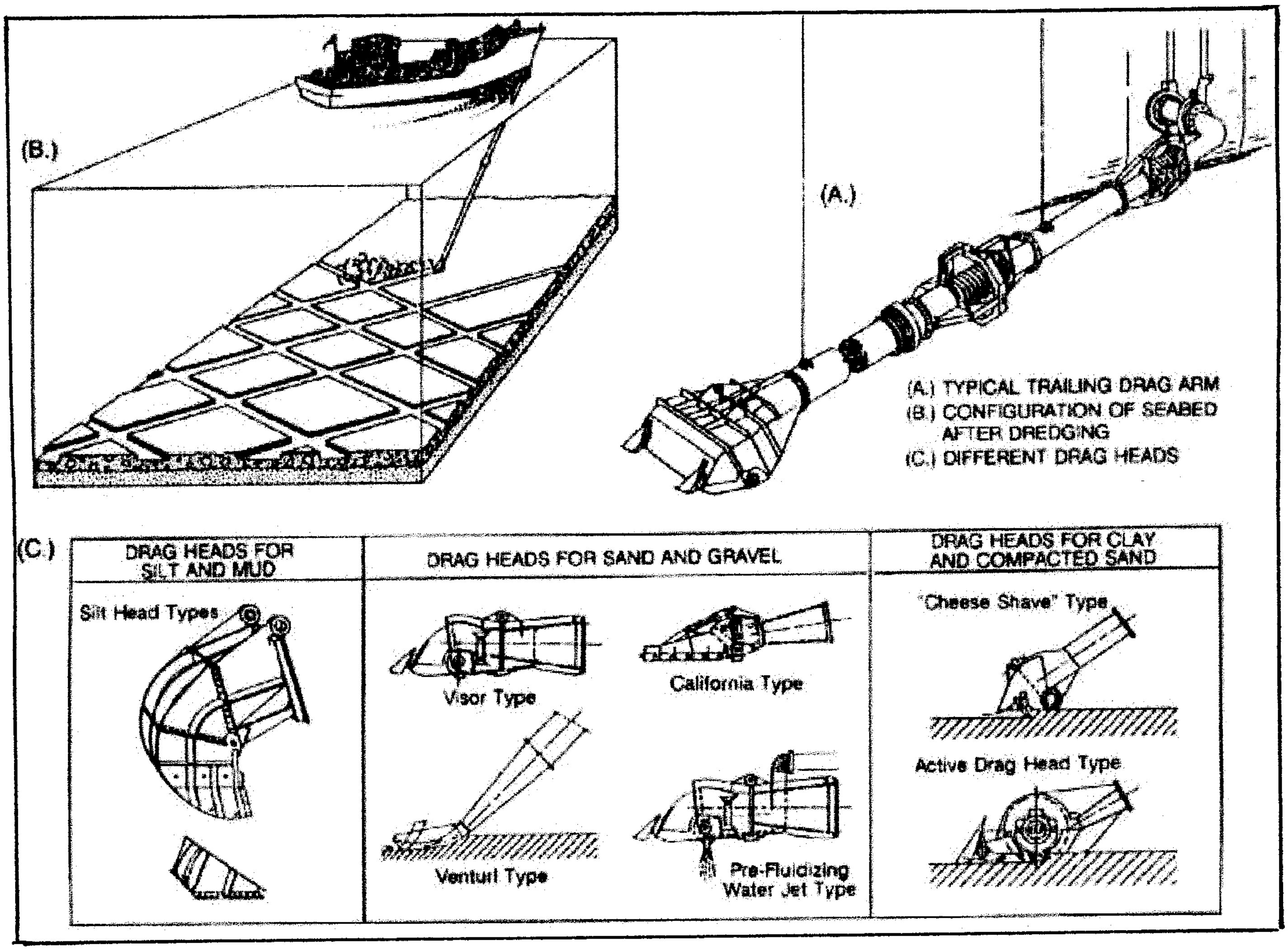

FIGURE 8
TRAILING SUCTION HOPPER DREDGE CONFIGURATIONS

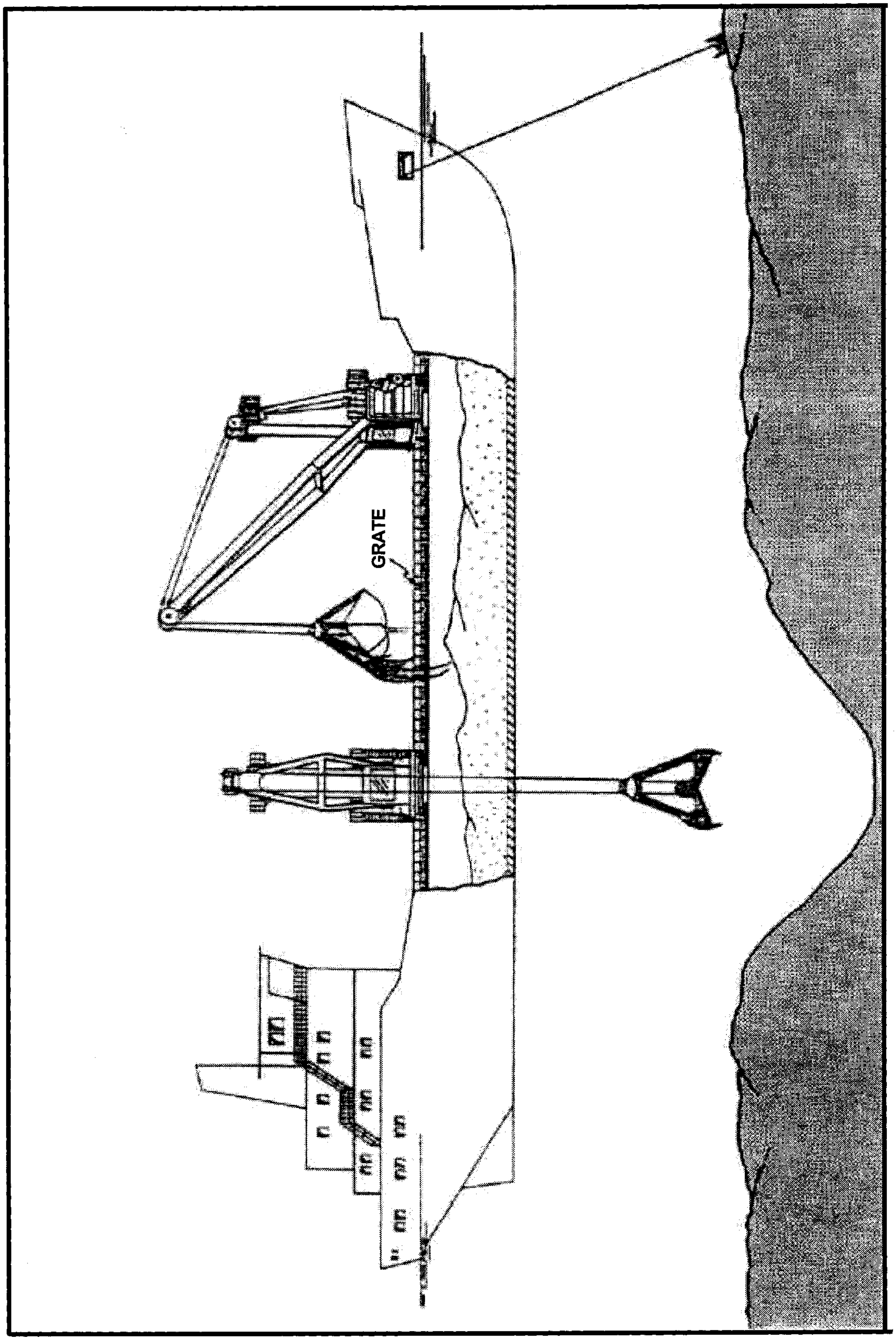

FIGURE 9
TYPICAL CLAMSHELL BUCKET DREDGE

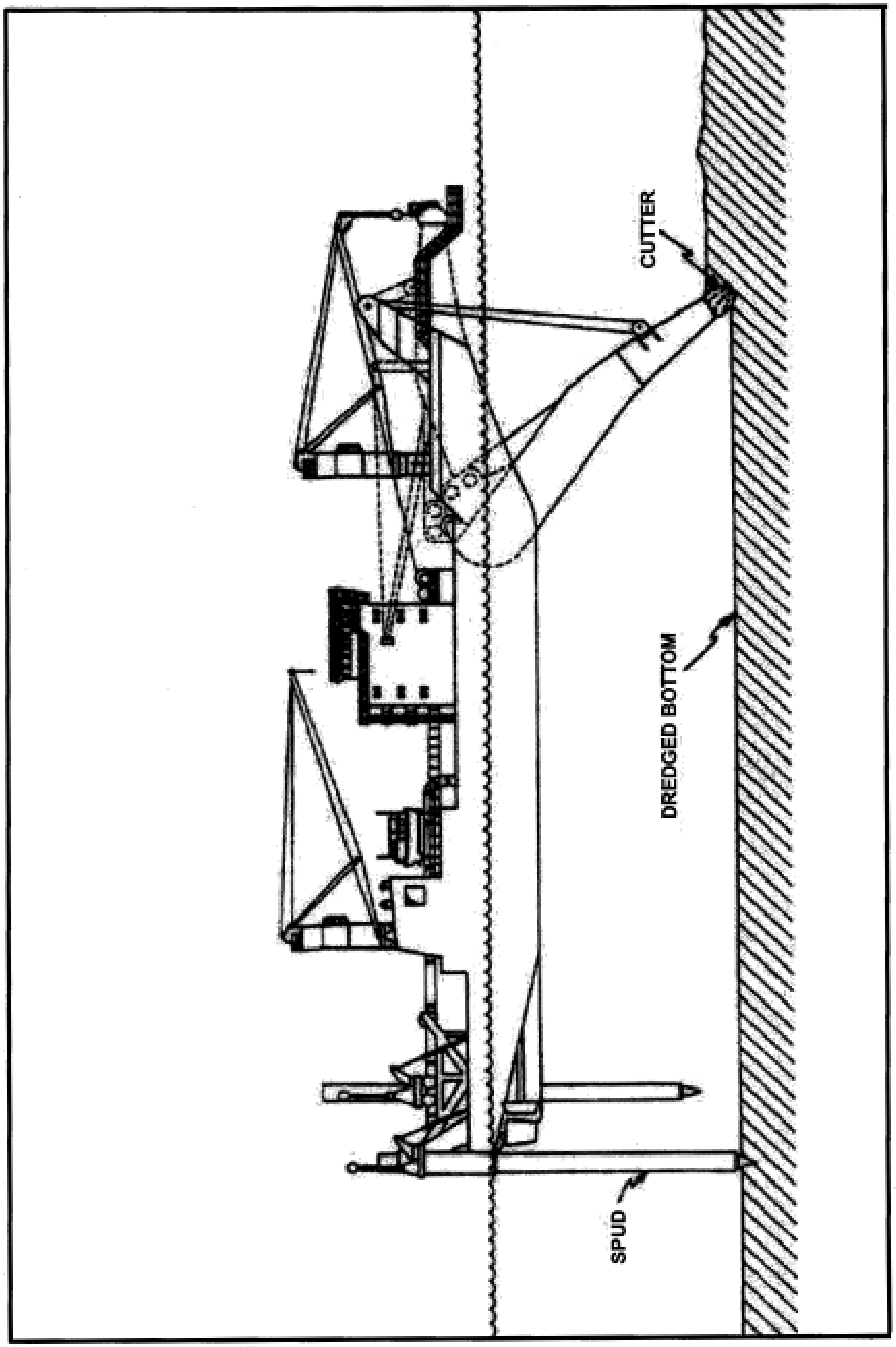

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FIGURE 11
CUTTERHEAD SUCTION DREDGE

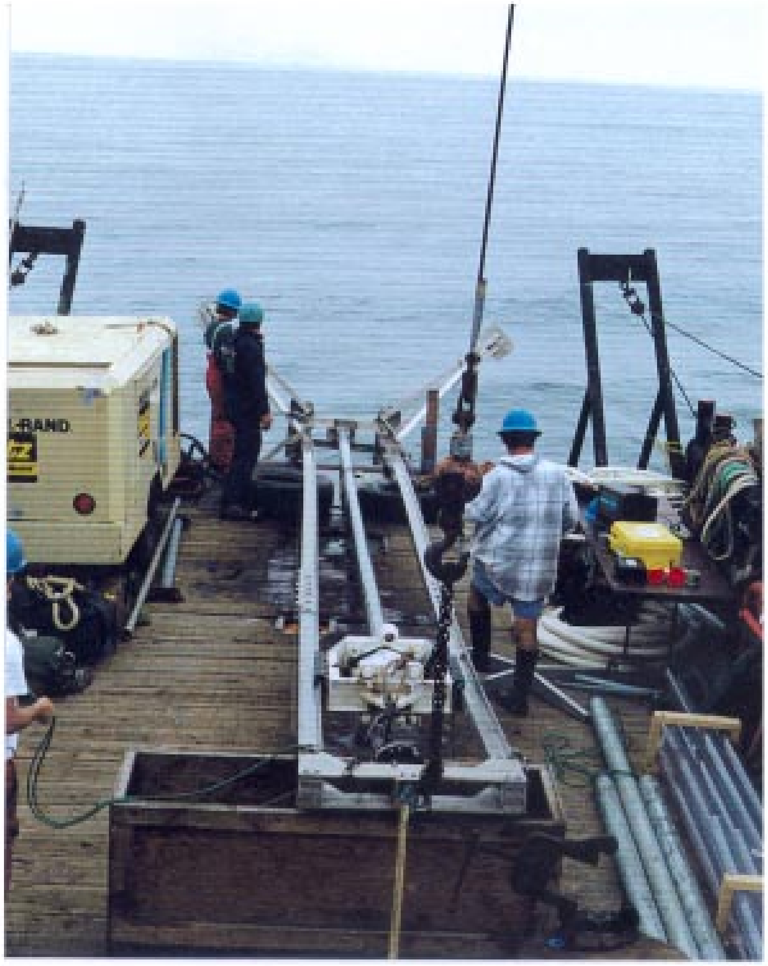

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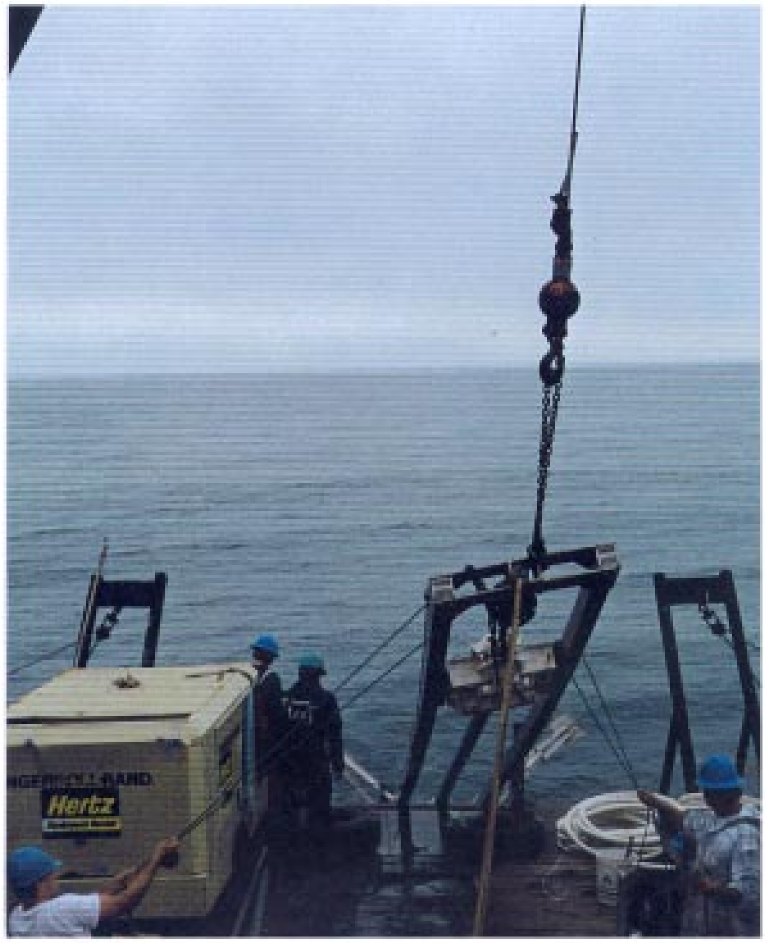
PLATE 1
VIBROCORING OPERATIONS



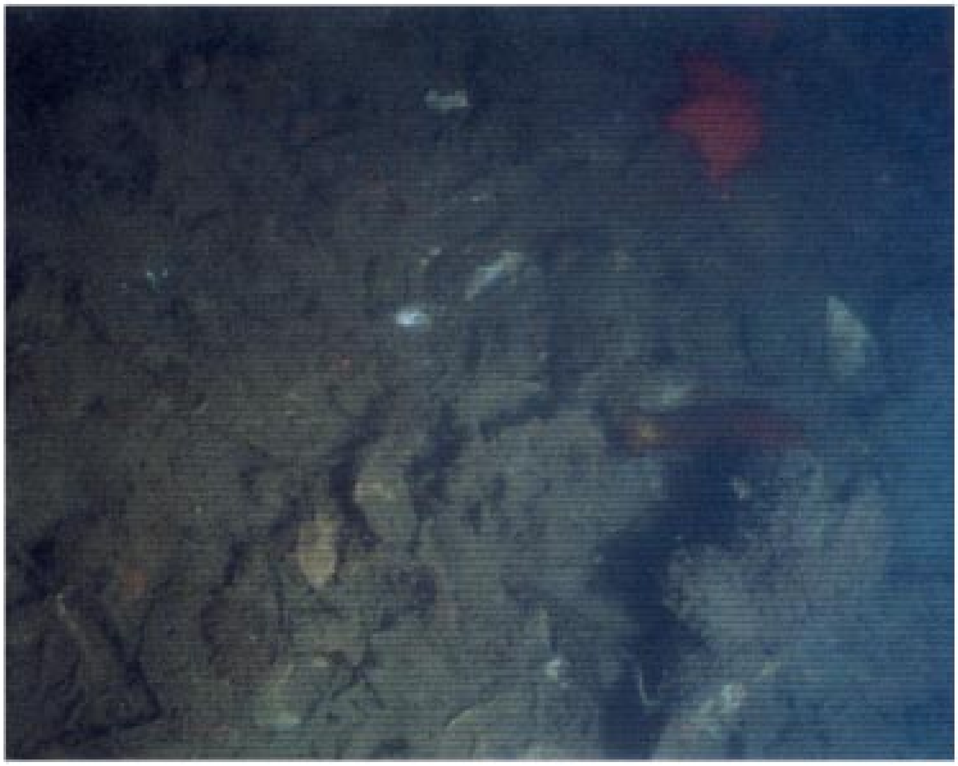
Deployment of Vibrocore

Recovering Vibrocore and Removing Core Barrel

<u>Extruding Core Liner from Core Barrel</u>

Core Liner and Examples of Core Samples

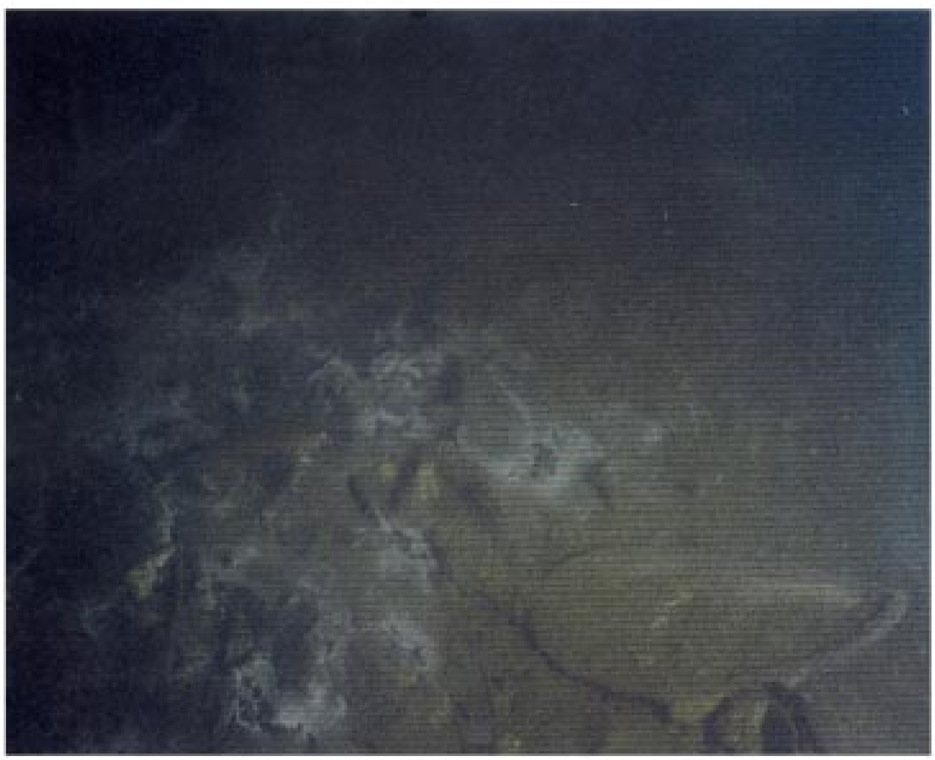
<u>Typical Sediment-Covered Shells with Sea Stars *Asternia miniata* and *Pisaster giganteus*</u>



Typical Sediment-Covered Shells with Bat Star *Asternia miniata*, a Sea Cucumber, *Parastichopus* sp., and the Chestnut Cowry Snail, *Cypraea spadicea*

Red Gorgonian Coral, *Lophogorgia chilensis* and Yellow Gorgonian Coral, *Muricea californica*

Red Gorgonian Coral, *Lophogorgia chilensis*, Solitary Coral, *Coenocyathus stearnsii*, Sea Cucumber, *Parastichopus*, sp., and Chestnut Cowry Snail, *Cypraea spadicea* on Concrete Platform Leg



Strawberry Anemone, *Corynactis californica* on Shells Around Base of Concrete Platform Leg, and White "Bacteria Film" on Sediment and Shells of Platform *Heidi*